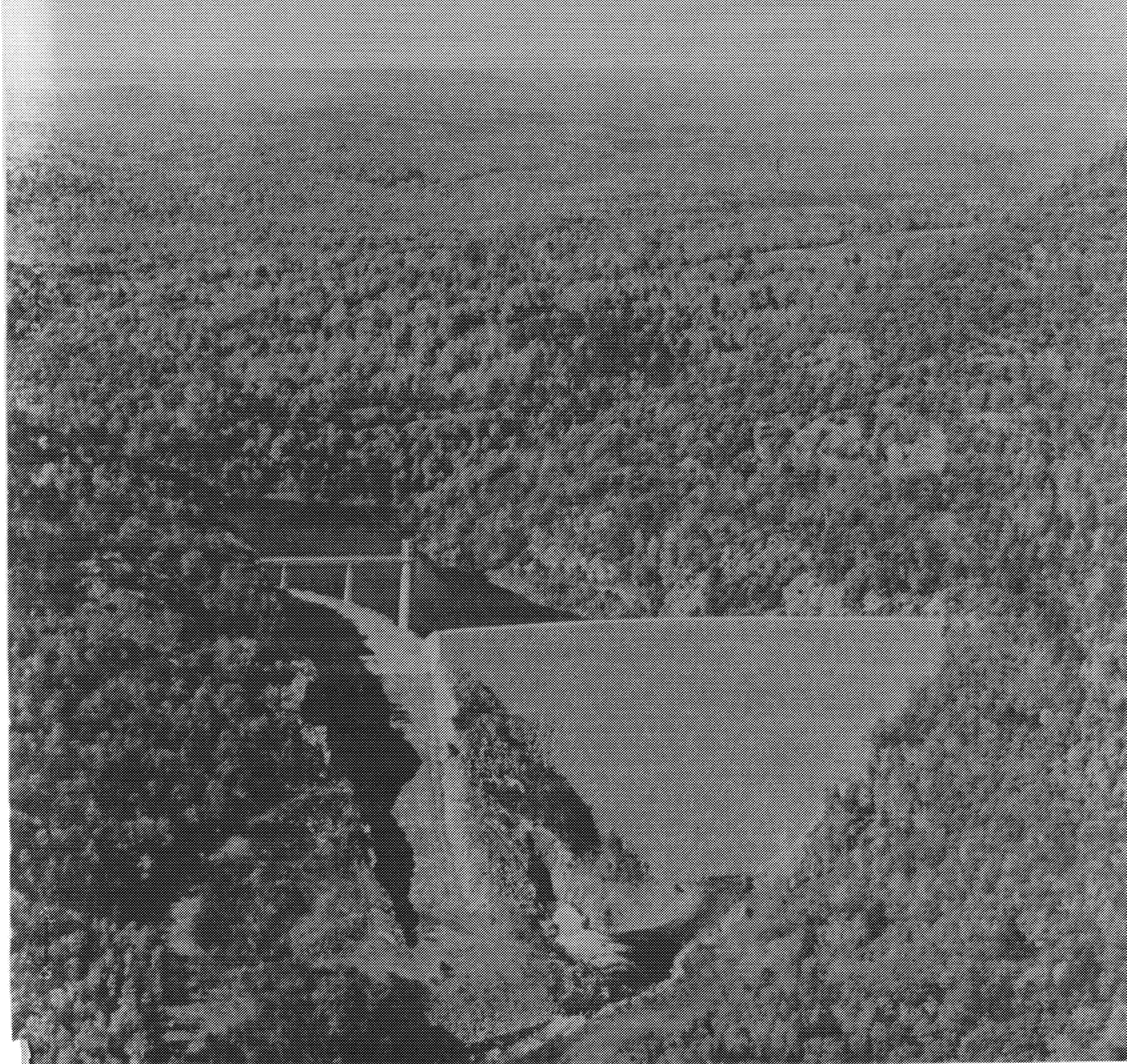
US Army Corps
of Engineers
New England Division

Hydropower Study

December 1982

Reconnaissance Report

Ball Mountain Lake, Jamaica, Vermont



HYDROPOWER STUDY

BALL MOUNTAIN LAKE

JAMAICA, VERMONT

RECONNAISSANCE REPORT

DECEMBER 1982

U.S. Army Engineer Division, New England
424 Trapelo Road
Waltham, MA 02254

FOREWORD

This report presents the results of a reconnaissance study of the feasibility of adding hydropower facilities to the existing Corps flood control project located on the West River at Jamaica, Vermont.

Using current Water Resource Council Principles and Guidelines criteria, the addition of hydropower facilities at Ball Mountain Lake has been found to be economically feasible. Consideration was given to a 2,200 Kilowatt installation which could generate 9,067 megawatt-hours annually at a cost of about 66 mills per kilowatt hour. Implementation of such a plan would require the raising of the winter reservoir level by 40 feet to the current summer pool elevation and on a permanent basis so as to create a head of water for power generation. The winter pool area of 20 acres is held at a surface elevation of 830.5 feet above National Geodetic Vertical Datum (NGVD), while a pool of 75 acres is maintained for a summer recreation use at surface elevation of 870.5 NGVD.

Funding constraints have limited the scope of this study effort to gathering baseline data from existing literature. Only run-of-river alternatives were considered. More comprehensive plans, involving storage or system coordination with proposed power development at the downstream Townshend Lake flood control reservoir, were not considered within the scope of the study. No detailed hydrologic, hydraulic, or reservoir regulation studies were accomplished. Design and cost estimates proposed for this report are of reconnaissance level of detail.

Detailed studies regarding social or environmental acceptability of the proposal have not been undertaken. Similarly environmental assessments and issues have not been considered. These and other issues will be investigated together with plans of development as this study progresses.

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BALL MOUNTAIN LAKE

Figure 1

I. INTRODUCTION

PURPOSE AND AUTHORITY

This is a reconnaissance report on the feasibility of adding hydroelectric facilities to the existing Corps of Engineers flood control project located in the towns of Jamaica and Londonderry, Vermont, on the West River. Authority for this study is contained in Section 216 of Public Law 91-611 (the River and Harbor Act of 1970):

> Sec. 216. The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures to their operation, and for improving the quality of the environment in the overall public interest.

SCOPE OF STUDY

This reconnaissance study was made to determine whether economically feasible hydropower development could be undertaken at the Ball Mountain Lake flood control project. The alternative run-of-river plans of hydropower development for the site were those considered to be compatible with the authorized purpose of the Federal project. Baseline environmental, recreational, social and cultural conditions of the study have been identified. Due to time and funding limitations only two alternatives were considered in this report. Several alternatives will be evaluated, including the possibility of a systems analysis of achieving maximum power benefits through coordination with hydropower development at the Corps' Townshend Lake flood control project located 9.5 miles downstream on the West River during the Feasibility Study scheduled for initiation in Fiscal Year 1983 pending approval of this Reconnaissance Report.

STUDY PARTICIPANTS AND COORDINATION

This study was conducted by the New England Division, Corps of Engineers. Information used in the preparation of this report was obtained from technical information and construction drawings complied for the Ball Mountain Lake project and from site inspections. Informal telephone communications were held with various State and local interests which provided useful data. The Federal Energy Regulatory Commission (FERC) provided input to the report.

THE REPORT AND STUDY PROCESS

This reconnaissance report is the product of the initial stage of investigation used by the Corps for planning potential development. In subsequent study efforts alternative plans will be formulated and evaluated, and finally an implementable plan may be identified and submitted to Congress for authorization and construction.

The multiobjective planning framework utilized by the Corps is designed to insure that a complete and systematic evaluation of alternative plans of development is accomplished. Problems, needs, concerns and opportunities are identified and addressed. Plans are formulated and evaluated and impacts are assessed. Public involvement is sought throughout the course of the study, and efforts are made to keep the public informed of the progress and significant findings.

The approaches used for this study are consistent with the "Principles and Standards for Planning and Evaluating Water Resources Projects," as amended by the President's Cabinet Council on Natural Resources and Environment and the National Environmental Policy Act of 1969.

As the study progresses, in-depth data will be complied to allow increasingly detailed evaluation and assessments of alternatives until it becomes possible to identify the optimum proposal from both economic and environmental viewpoints. The ultimate goal is to formulate a plan judged to be in the best public interest using the study findings and public involvement.

OTHER STUDIES

The Flood Control Act of 1944, under which the Ball Mountain Lake project was authorized, provided "that penstocks and other similar facilities, adapted to possible future use in the development of hydroelectric power, shall be installed in any dam authorized in this act for construction by the Department of the Army when approved by the Secretary of the Army on the recommendation of the Chief of Engineers and the Federal Power Commission." As a result of studies made for the New England-New York Inter-Agency Commission, it was found in 1955 that this site was not economically feasible for development of power or power storage.

The Federal Power Commission (FPC) subsequently reviewed the power potentiality of the proposed Ball Mountain project and developed a plan for its future adaptation to the possible combined purposes of power and flood control. A letter outlining the plan was forwarded to this office dated 20 August 1956. The plan considered by the FPC staff would raise the earthfill dam by 23 feet and would require a modified spillway channel with taintor gates atop the spillway crest. Reservoir capacity between elevation 1025 and 1065 NGVD would be reserved for flood control (55,000 acre-feet). Full power pool would be at elevation 1025 with maximum drawdown to elevation 960 providing 40,000 acre-feet of power storage. A short penstock to an underground power plant would develop a gross head of 365 feet.

Installed capacity would amount to about 20 MW capable of generating 55 million kilowatt-hours in an average year. The total estimated cost including the incremental cost of a higher dam, reservoir and power facilities amounted to $6,700,000 (1956 price level). With annual power benefits estimated at about $800,000, power development at the proposed project would be economically feasible.

In reply to this proposal, dated 8 November 1956, the New England Division indicated that "there would undoubtedly be considerable delay before construction of any power facilities would be undertaken. The investment of an extra $2,000,000 in construction cost at that time for future power would incur interest charges amounting to a considerable sum."

"In lieu of moving the spillway into the side of Ball Mountain to avoid a retaining wall between the dam and the spillway as proposed by FPC, the spillway would be located so that the retaining wall would be of considerably less volume. If and when a power installation were made at the project, the present retaining wall between the dam and the spillway could be removed and a wall suitable for the required higher dam and the spillway gates could be constructed for about the same cost as the investment in the extra rock excavation."

The outlet works as designed would be satisfactory for depths of water up to the top of the dam. Since spillway gates would be utilized for flood control operations after the installation of power generating facilities, no provision had been included for modification to the existing outlet works. It was the opinion of the New England Division, at that time, that the above discussed arrangements would adequately provide for future development of power facilities at this site.

The FPC concurred in the design, by letter dated 27 November 1956, noting that modification to the project would be deferred until such time as a power installation is made at the project, thus effecting a savings in interest charges on any initial additional investment for future power development at Ball Mountain reservoir project.

Construction of the dam and appurtenant works was initiated in April 1957 and completed in November 1961.

The FERC awarded preliminary permit No. 2838 on 2 February 1980 to the West River Basin Energy Commission, Inc., (WRBEC), to investigate the cost effective addition of hydroelectric generating facilities to the Ball Mountain Dam. WRBEC is a nonprofit, tax-exempt corporation formed in January 1978 to "study, coordinate, research and disseminate information of energy resources in the West River." The towns of Brookline, Dummerston, Langrove, Londonderry, Newfane, Peru, Stratton, Townshend, Wardsboro, Weston, Windham and Winhall were authorized by the voters at town meeting day, in 1978, to appoint representatives in development efforts.

In order to comply with FERC licensing requirements, Senate Bill #137 was submitted to the Vermont Legislature, at the request of WRBEC, to establish WRBEC as a utility authority engaged in the generation, transmission, distribution, sale and purchase of electricity. This Bill was passed by the Vermont Legislature and signed by the Governor with two important provisions added to the Bill. The first provision stipulates that the enabling authority will not become law until passed by the member Town meetings when they vote on the first Tuesday of March 1983. The 12-member towns are expected to approve of this measure.

The second provision of the Bill, inserted at the request of the town of Jamaica, stipulates that the WRBEC authority shall not exist unless the town in which the generation facilities are to be located is a member of the authority. Since the WRBEC generation facilities are to be located in Jamaica and Jamaica is opposed to joining as members of the authority, Ball Mountain could not be the subject of a license application by WRBEC since they would not legally meet FERC licensing requirements.

The WRBEC has subsequently studied three alternatives under the preliminary permit which are described later in this report. The study was completed in June 1981. The report recommends that a project be developed.

It is assumed that WRBEC will try to continue with the licensing procedures but as previously mentioned they currently do not meet FERC licensing requirements for a hydropower project at Ball Mountain.

There are no other known hydroelectric studies at Ball Mountain Dam. The Corps of Engineers completed a Master Plan for Recreation Resources Development in December 1977, an operations manual for the project in June 1972 and a reservoir regulation manual in September 1973.

II. PROBLEM IDENTIFICATION

NATIONAL AND REGIONAL OBJECTIVES

The primary purpose of the hydropower addition is to reduce dependence on oil for energy generation. The New England Power Pool (NEPOOL) has indicated that approximately 60 percent of the existing capacity of the region is contained in oil-fired generation units, which would be affected by fuel shortages that could occur in the immediate future. A hydropower addition to this project would displace oil generated energy, thereby reducing dependence on oil. Any hydropower development would have to be socially and environmentally acceptable to the local community. Any opportunities to enhance the environment through hydropower addition will be investigated and implemented where possible.

EXISTING CONDITIONS IN THE STUDY AREA

Physical Setting

The Ball Mountain Lake project is one unit of a system of 16 dams and reservoirs that have been constructed as a part of a comprehensive plan for flood protection in the Connecticut River Basin. The project is located on the West River, about 29 miles above its confluence with the Connecticut River at Brattleboro, Vermont. The dam is in the town of Jamaica and the reservoir extends 6.5 miles upstream into the town of Londonderry, both in Windham County, Vermont. A general plan and vicinity map are shown on Figure 2.

The major physical components of the project consist of an earth and rockfill dam, a concrete spillway and outlet works. Pertinent data for Ball Mountain Dam are summarized in Table 1.

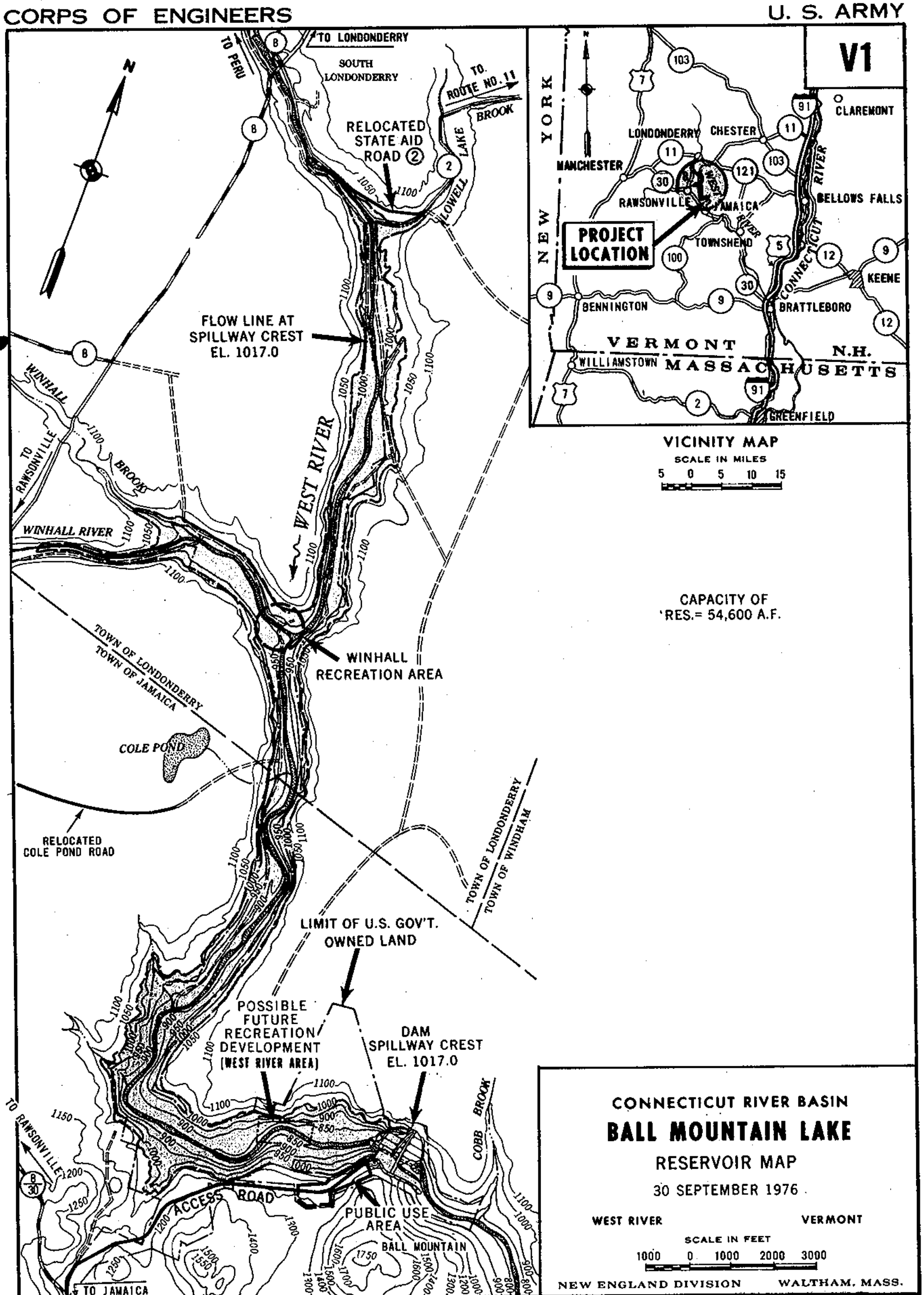

V1
TO LONDONDERRY
TO PERU
SOUTH LONDONDERRY
TO ROUTE NO. 11
RELOCATED STATE AID ROAD ②
LOWELL LAKE BROOK
FLOW LINE AT SPILLWAY CREST EL. 1017.0
WEST RIVER
WINHALL BROOK
TO RAWSONVILLE
WINHALL RIVER
TOWN OF LONDONDERRY
TOWN OF JAMAICA
WINHALL RECREATION AREA
COLE POND
RELOCATED COLE POND ROAD
TOWN OF LONDONDERRY
TOWN OF WINDHAM
LIMIT OF U.S. GOV'T. OWNED LAND
POSSIBLE FUTURE RECREATION DEVELOPMENT (WEST RIVER AREA)
DAM SPILLWAY CREST EL. 1017.0
COBB BROOK
TO RAWSONVILLE
ACCESS ROAD
PUBLIC USE AREA
BALL MOUNTAIN
TO JAMAICA
NEW YORK
LONDONDERRY
CHESTER
MANCHESTER
RAWSONVILLE
JAMAICA
WEST RIVER
TOWNSHEND
PROJECT LOCATION
CLAREMONT
BELLOWS FALLS
CONNECTICUT RIVER
KEENE
BENNINGTON
BRATTLEBORO
VERMONT
N.H.
WILLIAMSTOWN
MASSACHUSETTS
GREENFIELD
VICINITY MAP
SCALE IN MILES
5 0 5 10 15
CAPACITY OF RES.= 54,600 A.F.
CONNECTICUT RIVER BASIN
BALL MOUNTAIN LAKE
RESERVOIR MAP
30 SEPTEMBER 1976
WEST RIVER
VERMONT
SCALE IN FEET
1000 0 1000 2000 3000
NEW ENGLAND DIVISION
WALTHAM, MASS.

FIGURE 2

TABLE 1

PERTINENT DATA - BALL MOUNTAIN LAKE

Location: West River, Jamaica and Londonderry, Windham County, Vermont

Drainage Area: 172 square miles

Storage Use: Flood Control and Recreation

Reservoir Storage:

	Elevation (ft. NGVD)	Area (Acres)	Capacity (Acre-Feet)
Invert Elevation	805.5	0	0
Seasonal (Winter)	830.5	20	225
Seasonal (Summer)	870.5	75	2,240
Spillway Crest	1017	810	54,460

Embankment Features:

Type	Rock and Earthfill
Length (feet)	915
Top Width (feet)	20
Top Elevation (ft. NGVD)	1052
Height (ft. max.)	265
Base Width (ft. max.)	1200

Spillway:

Location	Right Abutment
Type	Chute, Concrete Weir
Crest Length (feet)	235
Crest Elevation (ft. NGVD)	1017

Outlet Works

Type	Reinforced Concrete Lined Tunnel
Conduit Inside Dimensions (feet)	13.5 Diameter
Conduit Length (feet)	864 (Excluding transition)
Service Gate Type	Three hydraulic gates
Service Gate Size (feet)	Three 5.67 x 10
Downstream Channel Capacity (cfs)	5,000
Maximum Discharge Capacity (Spillway Crest Elevation)	11,400 cfs outlet conduit
Stilling Basin	None

Lands: 965 acres have been purchased in fee to Elev. 985, Easements are taken to Elev. 1057

The chute type spillway with a concrete weir, 235 feet long, is located in the right abutment when looking downstream. The spillway crest elevation is 1017 NGVD.

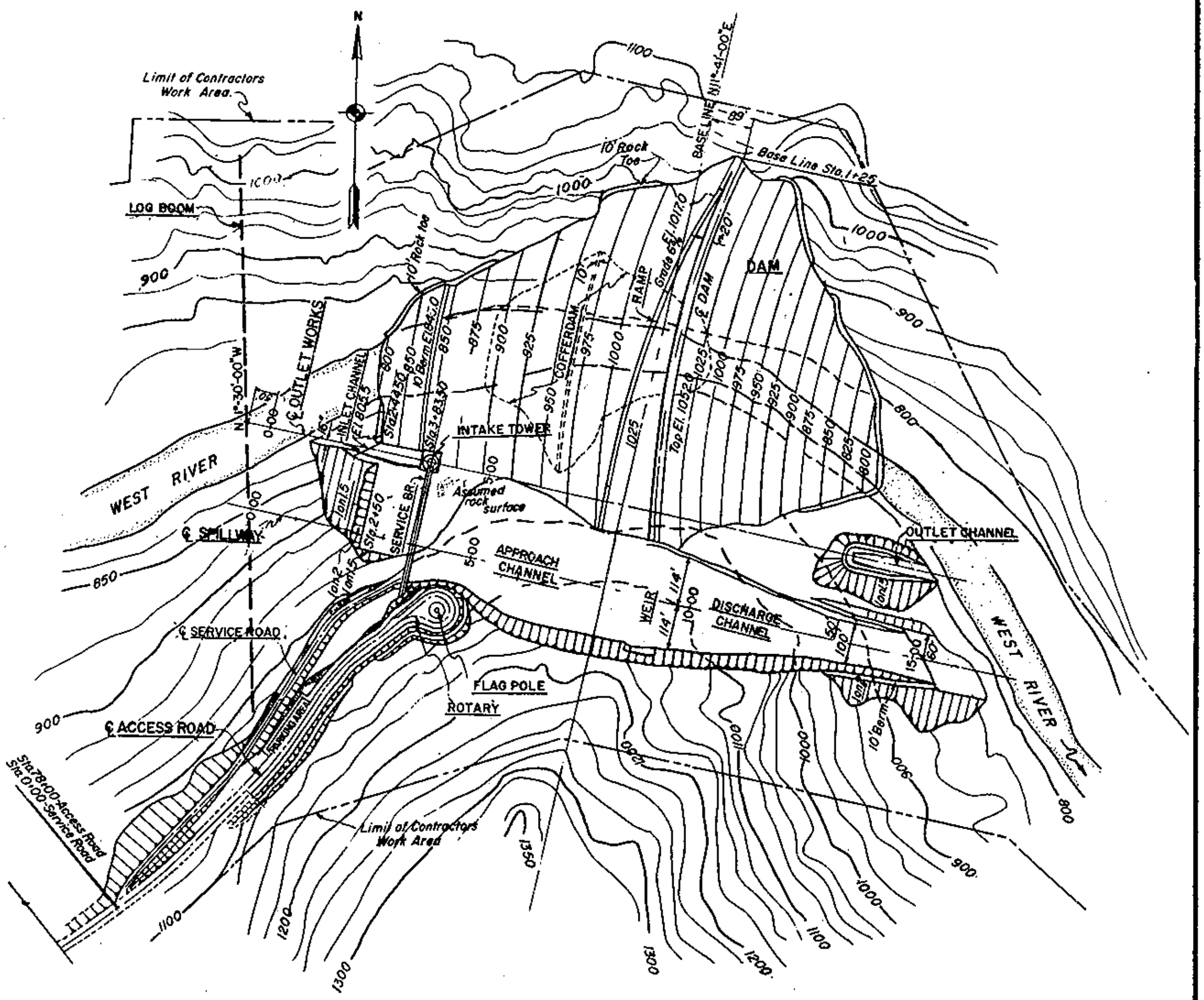
The outlet works, located adjacent to the spillway consist of a 13-foot 6-inch circular reinforced concrete lined tunnel under the dam. Discharges are controlled by three 5-foot 8-inch x 10-foot hydraulically operated gates from a gate tower at the intake end of the tunnel. A general plan and elevation of the dam is shown on Figure 3.

The total storage capacity of Ball Mountain Lake is 54,690 acre-feet when filled to spillway crest and would create a pool covering 810 acres. A conservation pool is maintained in the reservoir from late fall to the spring months up to elevation 830.5 NGVD. Flood control storage above this elevation would be equivalent to 5.9 inches of runoff from the 172-square mile drainage area. This winter pool covers 20 acres and utilizes a net storage of 2,000 acre-feet. A summer recreational pool is maintained at elevation 870.5 NGVD covering 75 acres at a maximum depth of 65 feet. Flood control storage above this elevation would be equivalent to 5.7 inches of runoff which is equivalent to 52,450 acre-feet. An area-capacity curve is shown as Figure 4.

The headwaters of the West River originate on the southeastern slopes of Mount Holly, Vermont. From its source the river flows south about 7 miles to the town of Weston, where it turns in a generally southeasterly direction for about 46 miles, through the towns of Londonderry, Jamaica and Newfane, to its confluence with the Connecticut River at Brattleboro, Vermont. The West River is part of the Connecticut River Basin which drains an area of 11,265 square miles. Figure 6 shows the entire Connecticut River Basin. The West River has a drainage area of approximately 423 square miles and a total fall of 1,780 feet of which 720 feet are in its upper 8 miles. The principal tributaries of the West River are Winhall River, Ball Mountain and Whetstone Brooks. Elevations vary from 220 feet NGVD at the mouth of the river, 800 at the damsite, to over 3,500 feet at several points on the watershed divide. Figure 5 shows a profile of the West River.

The general topography of the basin is hilly with steep wooded slopes from its mouth to Ball Mountain Dam area. The basin upstream from Ball Mountain is comparatively flat with wide valleys, but the rim of the watershed is steep and mountainous. There are a few natural or artificial ponds, and in general the drainage area is conducive to rapid runoff. The West River basin has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the path of cyclonic disturbances which cross the country from the west or southwest. The local climate is also affected by occasional coastal storms, some of tropical origin which travel up the Atlantic seaboard.

V1a



CONNECTICUT RIVER BASIN

BALL MOUNTAIN LAKE

GENERAL PLAN

30 JUNE 1974

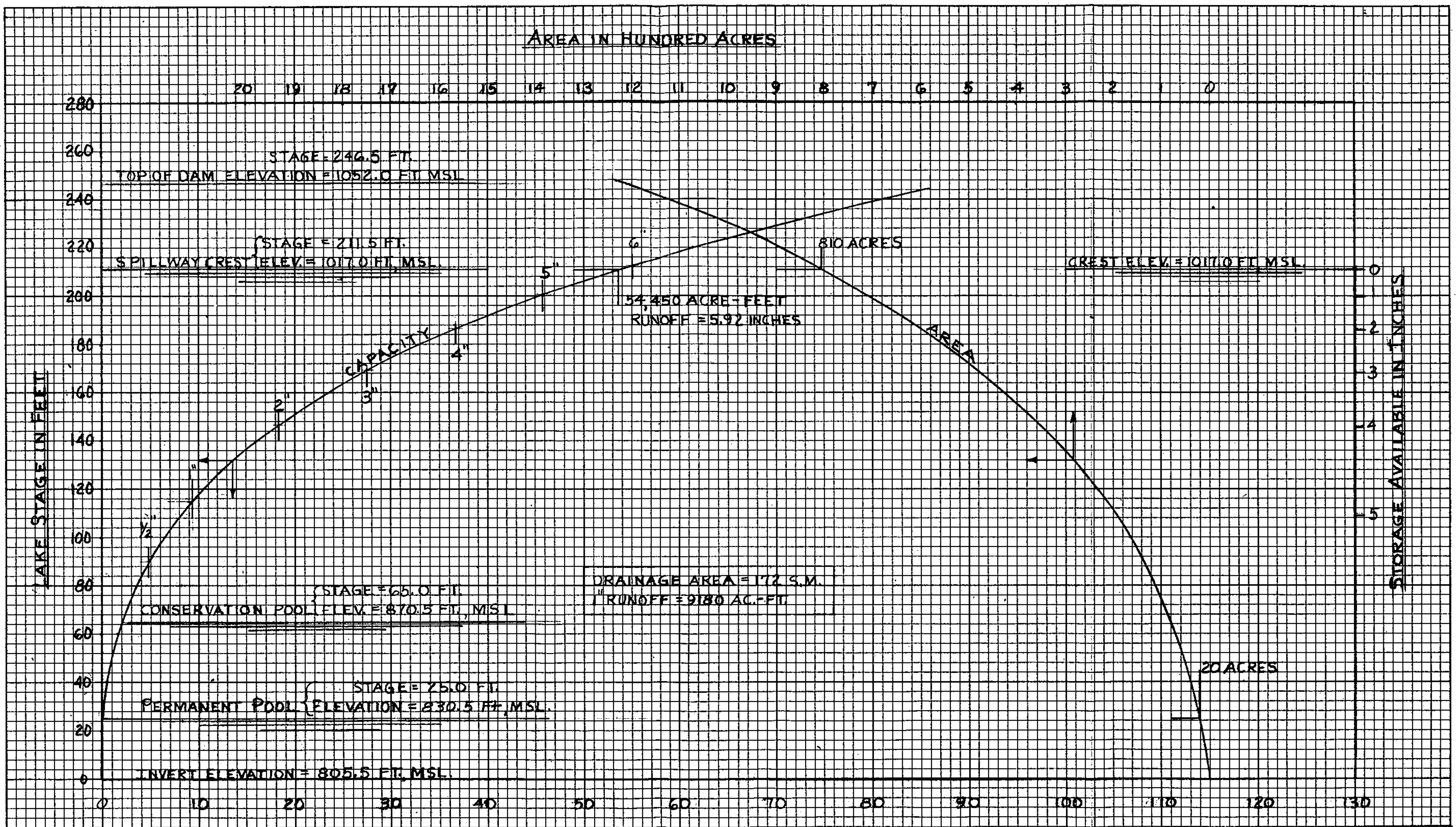
WEST RIVER VERMONT

SCALE IN FEET

100' 0 100' 200'

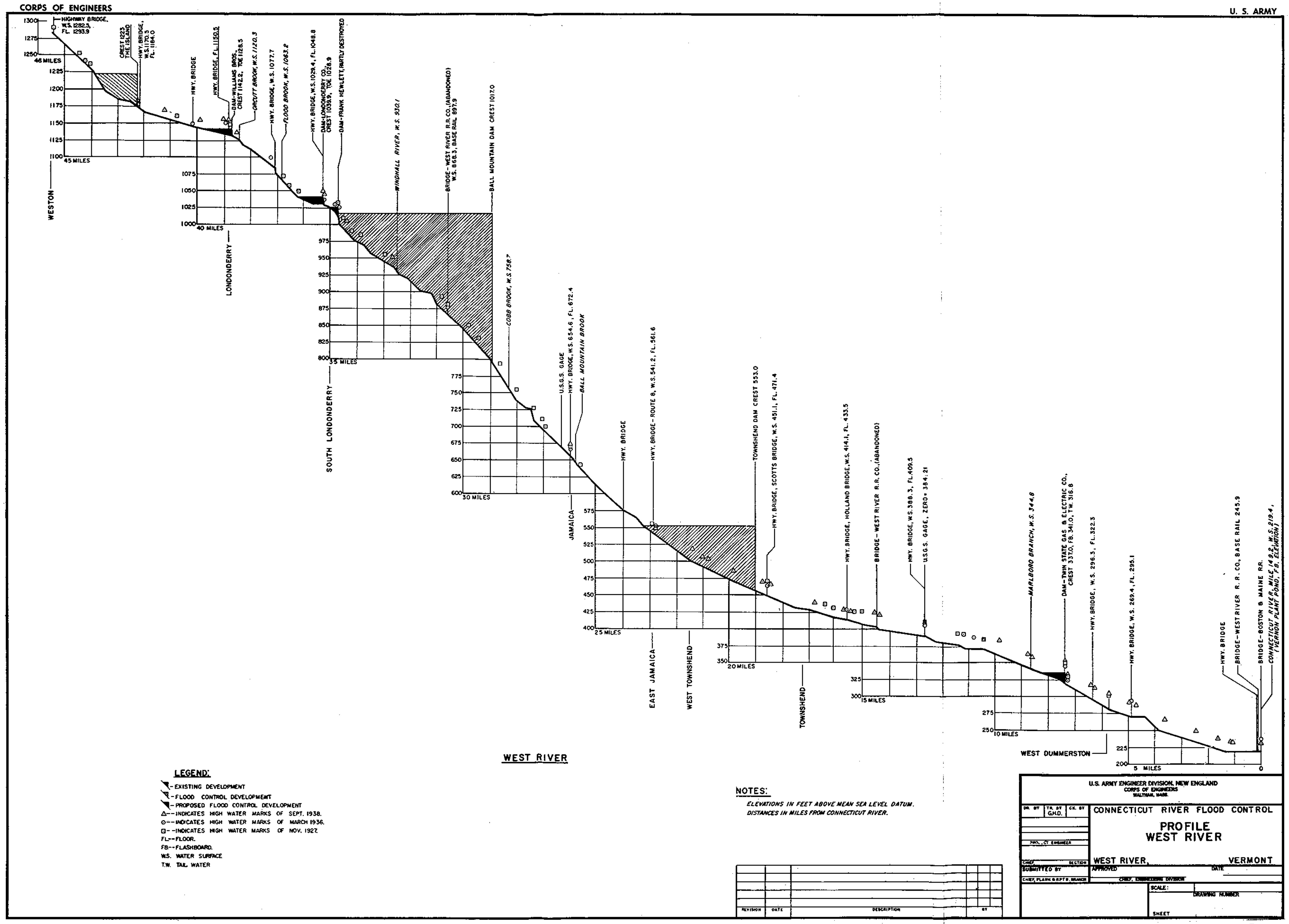
NEW ENGLAND DIVISION WALTHAM, MASS.

FIGURE 3



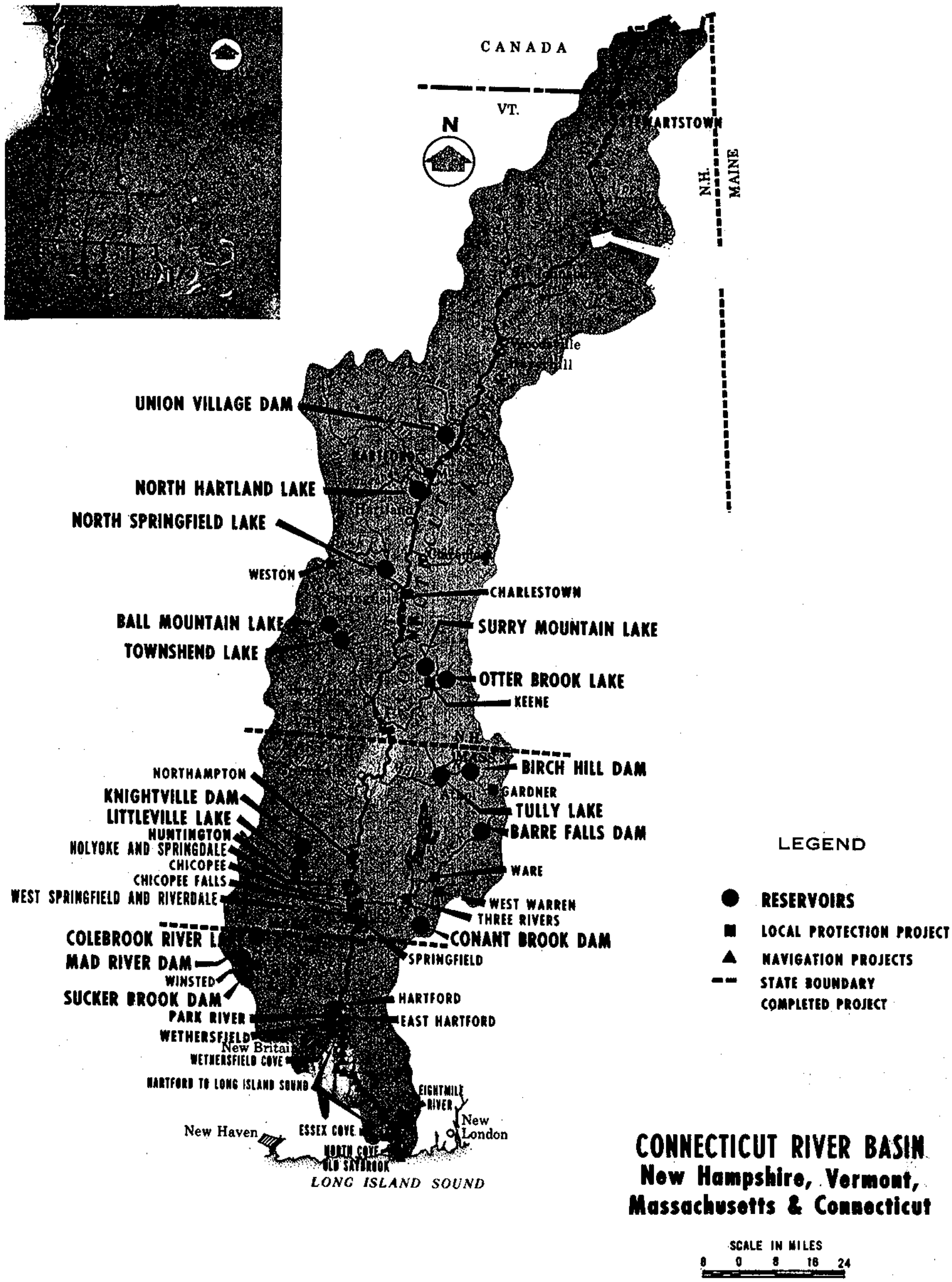
CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN LAKE
AREA & CAPACITY CURVES
NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1973

FIGURE 4



CORPS OF ENGINEERS
U. S. ARMY
WESTON
LONDONDERRY
SOUTH LONDONDERRY
JAMAICA
EAST JAMAICA
WEST TOWNSHEND
TOWNSHEND
WEST DUMMERSTON
HIGHWAY BRIDGE, W.S. 1282.5, FL. 1293.9
HWY. BRIDGE
DAM-WILLIAMS BROS. CREST 1142.2, TOE 1128.5
HWY. BRIDGE, W.S. 1077.7
FLOOD BROOK, W.S. 1063.2
DAM-FRANK HEWLETT, PARTLY DESTROYED
WINDHALL RIVER, W.S. 930.1
BALL MOUNTAIN DAM CREST 1017.0
COBB BROOK, W.S. 758.7
U.S.G.S. GAGE
BALL MOUNTAIN BROOK
HWY. BRIDGE
TOWNSHEND DAM CREST 553.0
BRIDGE-WEST RIVER R.R. CO. (ABANDONED)
U.S.G.S. GAGE, ZERO = 384.21
MARLBORO BRANCH, W.S. 344.8
HWY. BRIDGE, W.S. 296.3, FL. 322.3
HWY. BRIDGE, W.S. 269.4, FL. 295.1
HWY. BRIDGE
BRIDGE-WEST RIVER R. R. CO. BASE RAIL 245.9
BRIDGE-BOSTON & MAINE R.R.
46 MILES
45 MILES
40 MILES
35 MILES
30 MILES
25 MILES
20 MILES
15 MILES
10 MILES
5 MILES
0
WEST RIVER
LEGEND:
- EXISTING DEVELOPMENT
- FLOOD CONTROL DEVELOPMENT
- PROPOSED FLOOD CONTROL DEVELOPMENT
△-- INDICATES HIGH WATER MARKS OF SEPT. 1938.
⊙-- INDICATES HIGH WATER MARKS OF MARCH 1936.
⊡-- INDICATES HIGH WATER MARKS OF NOV. 1927.
FL-- FLOOR.
FB-- FLASHBOARD.
W.S. WATER SURFACE
T.W. TAIL WATER
NOTES:
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL DATUM.
DISTANCES IN MILES FROM CONNECTICUT RIVER.
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
DR. BY
TR. BY G.H.D.
CK. BY
CONNECTICUT RIVER FLOOD CONTROL
PROFILE
WEST RIVER
WEST RIVER, VERMONT
SUBMITTED BY
APPROVED
DATE
SCALE:
DRAWING NUMBER
SHEET

FIGURE 5



CONNECTICUT RIVER BASIN
New Hampshire, Vermont, Massachusetts & Connecticut

FIGURE 6

The basin experiences long cold winters and relatively mild summers. The average annual temperatures very from 40°F in the hills to 45°F in the valleys. Distribution of precipitation is rather uniform through the year averaging about 48.39 inches per year. During the winter months the precipitation is practically all in the form of snow. The snowfall varies from an average of less than 40 inches annually in the lower elevations to over 100 inches in the higher elevations of the Green Mountains. Snow cover usually persists throughout the winter especially in the higher elevations. The average maximum water content over the basin is about 7 inches and usually occurs in the latter part of March. Based on 34 years of record, the maximum annual runoff, adjusted for upstream storage and regulation, is 2.05 cfs per square mile. The rate of runoff is equivalent to 27.8 inches per year which is nearly 58 percent of the average annual precipitation over the basin. Figure 7 shows the West River Basin.

Within the flowage easement of the Ball Mountain reservoir the West River flows through a narrow steep-sided valley, flanked by Ball Mountain to the south and Shatterack Mountain to the north. The greater part of the reservoir area is undeveloped and heavily wooded. The Winhall River enters near the center of the reservoir and creates an arm of the reservoir extending up this stream in a westerly direction for about 1.7 miles. As previously described, summer and winter pools are maintained within the reservoir. Figure 8 is a topographic map of the project area.

The West River occupies a preglacial valley filled with glaciated fill and ungraded sands and gravels. At the existing dam, bedrock is generally exposed or at very shallow depths. The outlet tunnel and spillway cuts were excavated in rock and the intake tower and embankment retaining wall are founded on rock. Postglaciation degradation by the river has removed considerable glacial deposits but large boulders and rock outcrops occupy the river channel below the dam.

Environmental Setting

Water Quality

The waters of the West River and Winhall River upstream from Ball Mountain Lake are rated class B by the Vermont Legislature. Class B waters are suitable for bathing and recreation, irrigation and agricultural uses, good fish habitat, good aesthetic value, acceptable for water supply with filtration and disinfection. All streams in the watershed are further designated as types I or II. Type I applies to major spawning areas for salmonids; however, just which areas are type I and which are type II have not been delineated.

The West-Williams-Saxtons Basins Water Quality Management Plan, September 1975, Vermont Department of Water Resources, contains a recommendation by a Vermont Department of Fish and Game fishery biologist that the West River downstream from Weston and the Winhall River from Bondville Center to the West River be designated as type II. On this basis, the West River was assumed to be a Class B, type II stream.

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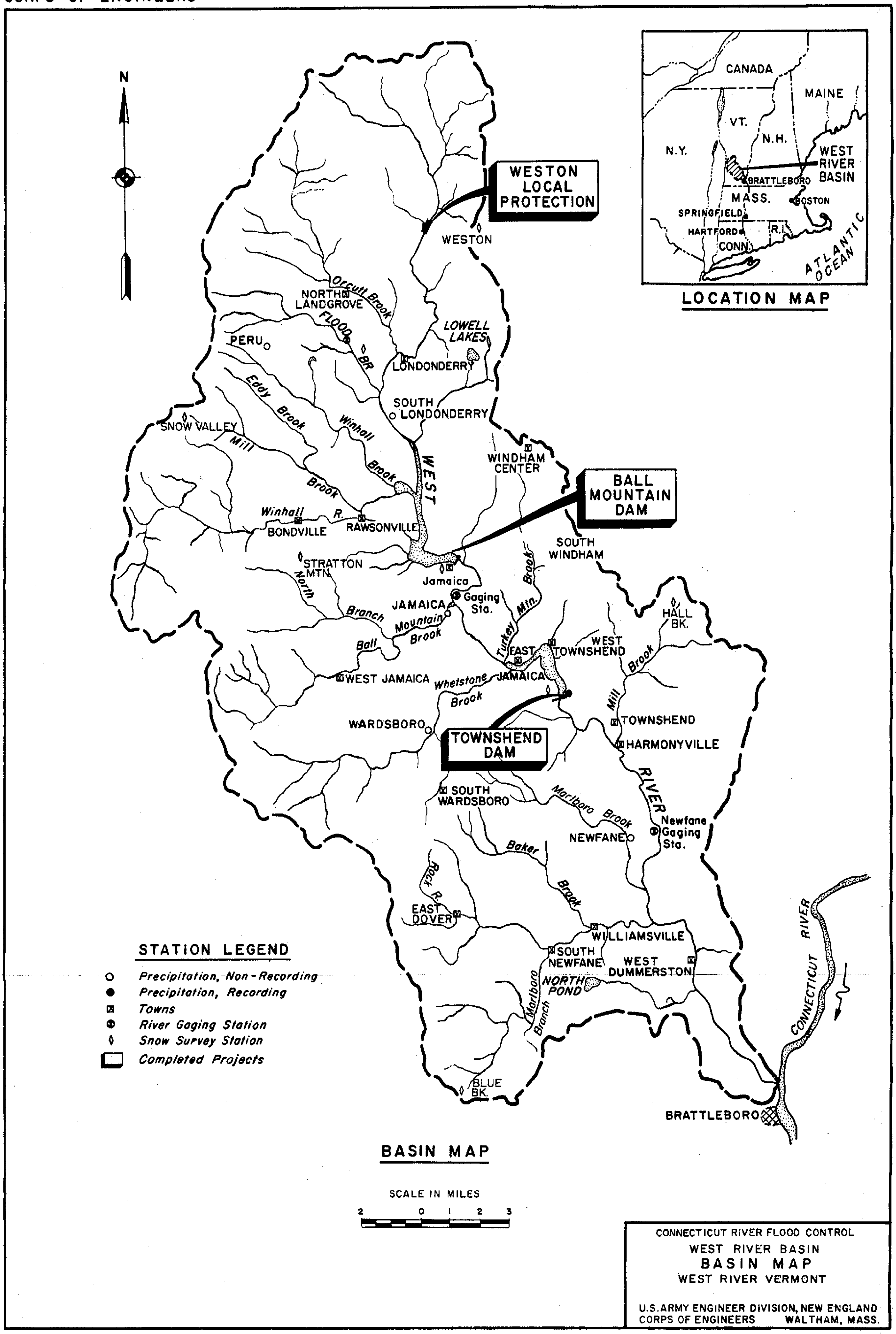
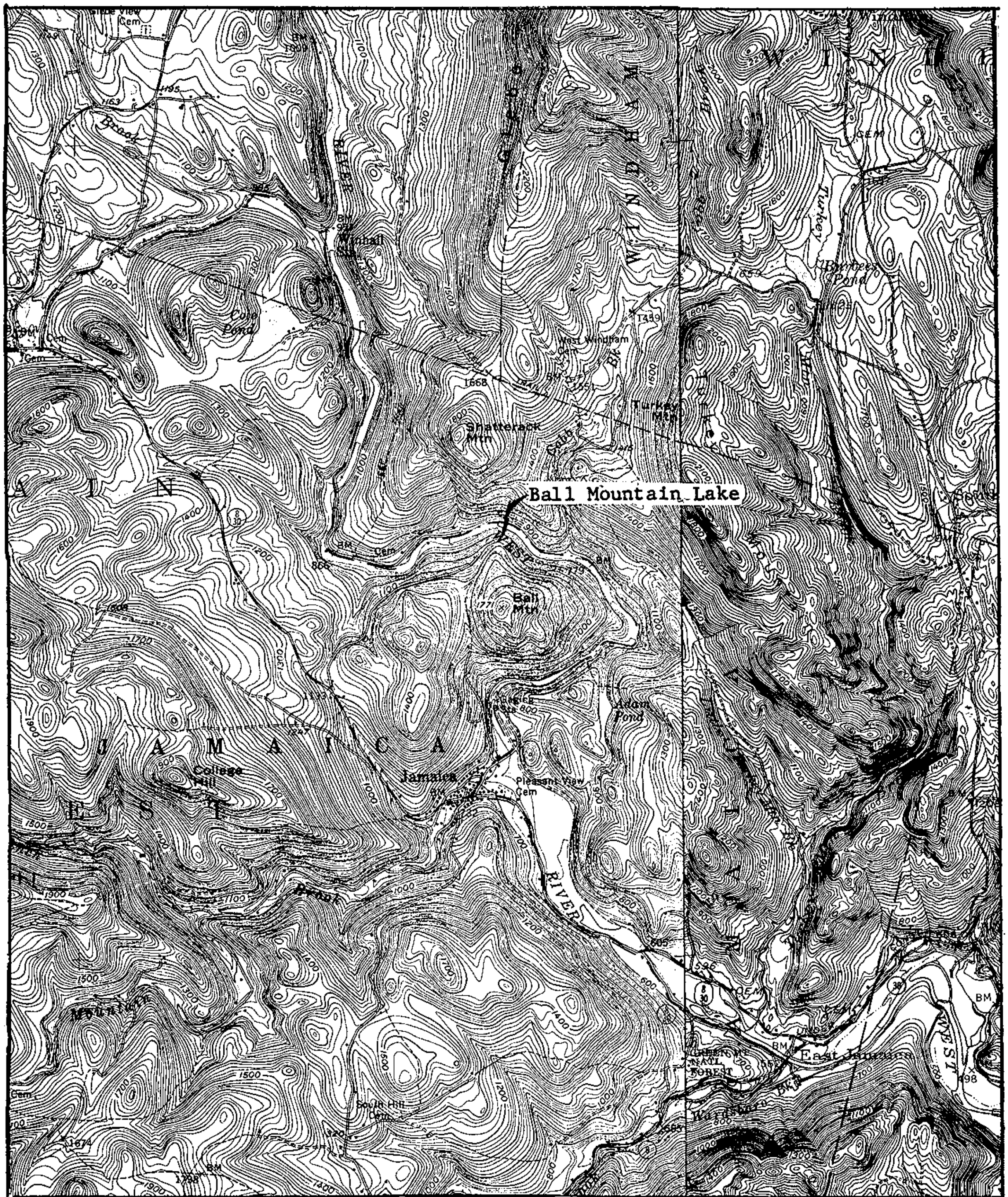


FIGURE 7



SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

U. S. GEOLOGICAL SURVEY

FIGURE 8

Water quality criteria for Vermont class B, type II waters were taken from the Vermont "Regulations Governing Water Classification and Control of Quality;" Quality Criteria for Water, US Environmental Protection Agency, 1976; Water Quality Criteria 1972, National Academy of Sciences, National Academy of Engineering; Water Quality Criteria, McKee and Wolf, 1963 and Water Quality Criteria Availability, US Environmental Protection Agency, 1979.

A brief review of the sources and basis for these quality criteria is outlined as follows. Water quality criteria have been selected on the basis that all multipurpose uses will be protected. Therefore, the use with the lowest required pollutant concentrations controls the selection of criteria. The criteria for turbidity, color, dissolved oxygen (DO), pH, total coliform, and fecal coliforms have been taken from the Vermont regulations. Parameters which are considered to effect sensitive resident aquatic species include ammonia-nitrogen, nitrite-nitrogen, fluoride, cadmimum, copper, lead, nickel, silver, zinc, antimony, and aluminum. Criteria for phosphorous were set to protect recreational and aesthetic uses of the river.

There are no known significant point source discharges upstream from Ball Mountain Lake, and the water quality at the project is high and usually meets or exceeds the State criteria. Exceptions include frequent violations of pH, color, coliform, and zinc criteria; rare violations of turbidity criteria, and very rare violations of DO criteria. Low pH levels are due to acid rain falling on pooly buffered Vermont soils; color violations are due to natural conditions in the watershed. High coliform counts are, according to a survey by the Vermont Department of Natural Resources, attributed to individual discharges in South Londonderry. High zinc levels have been recorded at all Ball Mountain Lake stations, but the data on these are incomplete and the source of the zinc is unknown. Turbidity levels at the lake are usually quite low but exceed criteria during storm runoff events. The cause of the very rare DO violations is not known but is probably due to natural conditions in the watershed.

Ball Mountain Lake is oligotrophic. Low levels of nutrients combined with a short hydraulic residence time in the lake keeps the biological productivity of the lake low and prevents the formation of nuisance algae blooms.

Ball Mountain Lake is 65 feet deep during the summer and experiences temperature-induced density stratification. However, because the inflows are cool and have a high DO content, the DO levels in the hypolimnion are typically greater than 5 mg/l and remain aerobic even towards the end of the summer stratification period.

Aquatic Ecosystem

Many different species of fish have been identified in the West River watershed. The principal game fish include brook and brown trout, small mouth bass, a limited number of large mouth bass and chain pickerel. "Panfish" such as bluegill, common sunfish, rock bass, yellow perch and brown bullhead are common to the streams and ponds of the area. Other species found include the long nose and common sucker, darter, sculpin, blacknose and long-nose dace, fallfish, creek chub, golden shinner and one or more species of killifish.Although the Vermont Fish and Game Department annually stocks trout in several streams in the upper West River watershed, there is no formal management of the fish resources within the reservoir by either the Corps of Engineers or the State of Vermont.

Terrestrial Ecosystem

Ball Mountain Lake lies in a deciduous forest vegetation zone characterized by American beech, yellow birch and sugar maple. Commonly associated conifers are hemlock and white pine. In the cooler higher elevations the forest is dominated by red, white and black spruces and balsam fir. Agricultural land is scarce due to the steep terrain and cool climate. Open farm land is confined to small patches of relatively flat or gentle sloped areas adjacent to the West River and its tributaries.

The southern Vermont area supports an abundant white-tailed deer population. A few black bear are found in the area. Other species of wildlife include cottontail rabbits, snowshoe hares, raccoons, red and gray foxes, ruffed grouse, and woodcock. Furbearers such as beaver, muskrat and mink may be found on the tributary streams.

Threatened and Endangered Species

There is a possibility that some rare or endangered species of animals or plants, especially birds, may occupy or frequent the project area, although none have been reported to date.

Cultural, Social and Economic Setting

Recreation and Natural Resources

Annual records of visitation at the project have been recorded since 1963. Fourteen years of record indicate an average annual attendance of 44,300 people. The major recreational activities in the project area, at present, are expressed in a percentage of total visitations: sightseeing - 70 percent, camping - 10 percent, picnicking - 8 percent, hunting - 3 percent, swimming - 3 percent, fishing - 1.6 percent and snowmobiling less than one percent. Present recreation facilities consist of the Winhall camping area, two overlook areas, picnicking areas with tables and fireplaces, a boat launching area, a swimming beach and a parking area at the dam. There is a 7-mile long snowmobile trail over gravel roads and an abandoned railroad bed.

Historic and Archaeological Resources

An investigation of suspected cultural resources in the reservoir area has been conducted by Peabody Museum of Harvard University under contract with the National Park Service. This study was conducted nearly 25 years ago with negative results. Since that time new field survey and recovery techniques and ethnographic analysis have been perfected so that the previous survey does not reflect the state of the art. As a result, the Corps is in the process of conducting another cultural resource reconnaissance to inventory all cultural resources within the project limits.

Population

The balance of population in the Ball Mountain area is contained in small towns and villages. Windham County experienced a population increase of 33.4 percent in the 1970-1980 decade, due in part to the overall increase in the standard of living which enabled the movement of people out of metropolitan areas of southern New England. A good percentage of growth is associated with recreational ski area developments, second homes and a diversification of light industry.

Population figures for the towns of Jamaica and Londonderry, Windham County and the State of Vermont are presented in Table 2.

TABLE 2

POPULATION

Year	Jamaica	Percent Change	Londonderry	Percent Change	Windham County	Percent Change	State of Vermont	Percent Change
1940	567	-	859	-	27,850	-	359,200	-
1950	597	5.3	953	10.9	28,749	3.2	378,000	5.2
1960	496	-20.0	898	-6.1	29,776	3.6	390,000	3.7
1970	590	19.0	1037	15.5	33,476	124	444,732	14.0
1980	681	15.4	1510	45.6	36,933	10.3	511,456	15.0

The State of Vermont as a whole has an average population density of 55 individuals per square mile based on a land area of 9,276 square miles. Windham County's population density is 56 persons per square mile.

Economy

The paper and printing industries, along with wood products, form the major economic base for activity in the West River watershed. Expansion of small manufacturing plants into the nearby Brattleboro, Vermont area, due to the interstate highway system, has increased employment opportunities resulting in much of the economic diversity. There are nine ski areas located within a 15-mile radius. Service employment in Windham County during the winter is often 30 percent higher than the annual average to accommodate skiers and other winter sports enthusiasts.

The West River Basin supports some dairy farming, sheep raising and other minor agricultural activities, but on the whole agriculture has been surplanted by retail services and light industry. Apples are an important crop to the area. Efforts are being made to increase production of this crop.

Reservoir Regulation

The Ball Mountain Lake and Townshend Lake flood control projects form part of a coordinated flood control plan for the Connecticut River Basin. The dams operate primarily to desynchronize flood flows of the West River from flood flows in the Connecticut River. These reservoirs, along with others in the Connecticut River Basin, are coordinated to obtain maximum reduction in overall flood damages at major industrial centers located on the mainstem of the Connecticut, such as Holyoke and Springfield, Massachusetts, and Hartford, Connecticut.

During the month of May and following the spring snowmelt period, the pool is raised to a stage of 65 feet for use as a conservation pool. This pool is maintained by throttling one gate with the other two gates closed. During a rising pool the throttled gate may be opened to a maximum of 4 feet by the project manager. However, if the pool rises above 75 feet, the Reservoir Control Center located in Waltham, Massachusetts is notified, and instructions are issued on gate settings desired.

During flood periods all flood control gates at Ball Mountain Dam are further throttled, or closed if necessary, to reduce flood stages on the West River and Connecticut River. During flood control operations a minimum discharge of at least 10 cfs is maintained to sustain fish life in the river immediately downstream of the dam.

Following the downstream recession of a flood on the Connecticut River, stored floodwaters are emptied as rapidly as possible, consistent with the amount of reservoir storage utilized, downstream flows, channel capacities, weather forecasts and travel times. The rate of discharge from Ball Mountain Reservoir is related to that of Townshend Reservoir and restricted to the nondamaging channel capacity below the dam of 5,000 cfs. Whenever discharge from Townshend is restricted due to downstream conditions, discharge from Ball Mountain is prorated to available storage in the two reservoirs and the outflow from Townshend Reservoir.

Periodically when requested, the Corps stores and releases water from the Ball Mountain Reservoir for white water canoe races held on the West

River in Jamaica by the American Canoe Association. The races are held during the first weeks of May as natural riverflow beyond this date often recedes rapidly and holding storage from spring runoff beyond this date is not desirable. Water is also stored and drawn down during the Columbus Day weekend to accommodate the canoeing interests.

FUTURE CONDITIONS WITHOUT THE PROJECT

No significant changes are envisioned to occur in the physical, environmental, cultural, social and economic conditions nor in reservoir regulations. However, the projected population growth in the area could result in gradual changes in the environmental setting and water quality of the West River.

PROBLEMS, NEEDS AND OPPORTUNITIES

New England depends heavily on oil as a fuel source for its electric generation. About 60 percent of the region's electricity is produced by oil-fired units. Given the instability of oil supplies and fluctuating prices associated with them, the need to develop power from renewable resources fueled projects is apparent. The addition of hydropower to the Ball Mountain Lake project would help to reduce the region's dependency on oil for production of electricity.

PLANNING CONSTRAINTS AND GUIDANCE

General planning constraints and guidance for this investigation are contained in Public Law 91-190, National Environmental Policy Act; Public Law 91-611, Flood Control Act of 1970; Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972; Public Law 93-251, Water Resources Development Act of 1974; Public Law 95-217, Clean Water Act; and the "Principles and Standards for Planning Water and Related Land Resources" guidance as amended by the President's Cabinet Council on Natural Resources and Environment.

Specific guidance is found in the new Civil Works Planning Guidance Notebook prepared and issued by the Department of the Army.

The primary purpose of the Ball Mountain Lake project is flood control, and any hydropower addition to this project must not interfere significantly with that purpose.

In the design of any hydroelectric facilities, measures must be taken, to the extent possible, to minimize environmental and social disruptions and still optimize the power potential of the site.

Funding constraints have severely limited the scope of studies associated with preparation of this reconnaissance report. Thus, the preliminary hydrologic studies associated with assumptions regarding possible infringement on existing flood control storage and impacts on reservoir regulation activities, as well as design and cost estimates, reflect this limitation. Future studies of hydropower development will address these constraints in detail to determine whether any infringement would have significant effect on the Connecticut River Basin flood control protection.

PROBLEM AND OPPORTUNITY STATEMENT

The hydroelectric additions being considered are contemplated to provide a project having a 50-year life cycle. The purpose of the development would present an opportunity to:

- Increase New England's energy supply and the Nation's energy independence.

- Develop and utilize an indigenous renewable energy fuel source to its maximum potential

III. FORMULATION OF PLANS

PLAN FORMULATION RATIONALE

The purpose of this investigation is to determine the feasibility of adding hydroelectric facilities to the Ball Mountain Lake project. In view of the limited scope of this study, it was decided that only run-of-river hydropower alternatives would be considered at this time. Two alternatives have been formulated by the Corps: both are intended to displace generation from oil-fired thermal facilities. The alternatives are based on using incoming flows on a daily basis (run-of-river), thereby limiting pool fluctuations to less than 2 feet. No attempt was made to determine the potential effect that storage could have on hydropower operations.

Studies of combining the regulation of flows with power generation at the downstream Townshend Lake flood control project were not addressed due to the limited funding for this study. Such potential will be addressed during subsequent detailed investigations.

PLANS OF OTHERS

As previously noted, WRBEC currently holds a FERC preliminary permit on Ball Mountain Dam and has developed three alternatives for power development. All schemes considered were designed to optimize the potential power production of the resource. It is suspected that the schemes evaluated by WRBEC would be operated on a store and release mode. This type of operation results in large fluctuations of the pool and could infringe on flood control storage. The Corps will not allow development of facilities that interfere with the existing authorized purpose of the Corps project. Therefore, infringement on flood control storage would not be allowed. Large pool fluctuations result in sloughing of the shoreline and funds to resolve this problem would be required to be set aside before approval would be granted.

Scheme A would locate a powerhouse at the existing downstream toe of the dam, adjacent to the outlet works. The existing outlet tunnel would be extended downstream approximately 80 feet by a steel penstock 11.5 feet in diameter. An 8-foot diameter bypass would branch from the penstock to a bifurcation which would divide power flow between a 6.9-foot diameter intake and a 4.4-diameter intake for two turbines of unequal size. The proposed installed capacity would be 4,740 KW. The estimated generation is 11,788,000 kilowatt hours per year.

Scheme B would locate a powerhouse about 4.5 miles downstream from Ball Mountain Dam using a new diversion tunnel about 6,800 feet in length through Ball Mountain to a point on the river near the village of Jamaica. The project would contain two turbines of unequal size similar to Scheme A in order to operate at a higher efficiency for a wide range of flows. The proposed installed capacity would be 11,550 KW with an average annual generation of 27,601,000 kilowatt hours of energy. This scheme has been chosen by WRBEC as having the largest potential for development. The project would be operated manually on a store-and-release mode and is considered an intermediate and peaking power plant.

Scheme C would provide a 10-foot diameter penstock from the dam outlet to a powerhouse located downstream of the Jamaica State Park. The penstock would follow an old railroad track bed for a distance of 7000 feet to the powerhouse site. Preliminary computations precluded this arrangement due to serious environmental restrictions and the impracticability of constructing a surge tank over 150 feet high close to the State Park. Thus Scheme C was eliminated from further consideration.

CORPS HYDROPOWER ESTIMATES

The hydropower potential of a volume of water is the product of its weight and the vertical distance it can be lowered. Water power is the physical effect of the weight of falling water. It is considered a source of power when it can be feasibly harnessed to perform useful work - particularly to turn wheels and generate electricity. The amount of water power developed from any stream, river or lake is measured primarily by: (1) the available rate of water flow and (2) the head that is available. Both the rate of discharge and the head are quantities which may fluctuate. It is, therefore, the magnitude of these two quantities and their variability that determine the potential energy of a site and its dependability.

Capacity, the rate of power generation, at any point in time, normally measured in kilowatts is determined by the formula:

$$P = \frac{EHQ}{11.8}$$

where:

- P = Power or capacity in kilowatts
- E = Combined turbine and generator efficiencies
- Q = Rate of discharge in cubic feet per second
- H = Net hydraulic head

The amount of power generation over a period time, "energy" is normally measured in kilowatt-hours and is equal to the average capacity times the duration of generation.

The capacity and energy estimates made in connection with this study assumed an average turbine-generator efficiency of 80 percent. The net hydraulic head of 80 feet was taken as the difference between the average surface elevation of the summer time recreational pool of the reservoir and the normal tailwater elevation at the powerhouse location. Only run-of-river type operation was assumed. The WRBEC schemes that were evaluated are believed to be designed to be operated in storage and release modes and therefore not useful for comparison to Corps estimates for generation available at the site due to the difference in operation of the facilities.

The U.S. Geological Survey gaging station (gage 01155500) located on the West River at Jamaica, Vermont (2.8 miles downstream of Ball Mountain Dam) was used for calculation of flows at the project. Flows were calculated at the dam by multiplying the recorded flows by the drainage area ratio of Ball Mountain Lake and the gage.

Based on 34 years of streamflow records, the average flow at the site is 353 cfs. The average annual runoff at Ball Mountain Lake is approximately 27.8 inches, or nearly 58 percent of the annual precipitation, equivalent to an average runoff rate of 2.05 cfs per square miles of drainage area. Table 3 shows average monthly flow data at the gaging station.

A flow duration curve is a graphical representation of discharge rate versus percent of time. As such, the flow duration curve is a measure of the magnitude and variability of flow. It does not account for the sequence or time at which flows of various magnitudes occur. Since the area under the curve represents the average amount of water available, it is possible to estimate average annual generation within the operating range of flows for the selected unit. An average annual flow duration curve based on an analysis of daily flow records for the period of record (1946-1980) is shown on Figure 9.

There are two basic classes of hydraulic turbines, namely, impulse and reaction turbines. Impulse turbines are driven by kinetic energy produced by jets of water impinging on buckets attached to the runners. Reaction turbines are driven by the combined pressure and velocity of water passing through blades attached to the runner.

In general, an impulse turbine will not be competitive in cost with a reaction turbine where the head is less than 1,000 feet. Reaction turbines have two basic types of runners. Francis which has fixed vanes and propeller which can have fixed or variable blades. These turbines may be mounted with vertical or horizontal shafts and the typical operating range of flows may vary from 40 to 105 percent of the design discharge. Francis turbines operate over a wide range of flows with effective heads ranging from 25 to 200 feet. Propeller turbines operate under a similar range of flows and may be used for design heads up to 100 feet.

Generators are either synchronous or induction types. The synchronous unit is equipped for self-excitation and synchronization before going onto the power grid, whereas, the induction generator relies on power from an outside source for excitation. Induction generator are somewhat cheaper and more applicable to small power installations but utility companies are reluctant to have numerous small units attached to the power supply system because they could cause a draining effect from the grid for excitation. For this study, synchronous generators were assumed for all alternatives. Generators would have rated capacities equal to or greater than the rated turbine capacity and also be capable of operating continuously at a 15 percent overload.

For estimating the hydropower potential at Ball Mountain Lake, it was assumed that the maximum power pool elevation, without causing significant effects on flood control would be the present summer pool elevation of 870.5 feet NGVD, which would provide a head of 65 feet. Further analysis of the selected pool elevation and its effect on flood control would be a part of any future more detailed hydropower study.

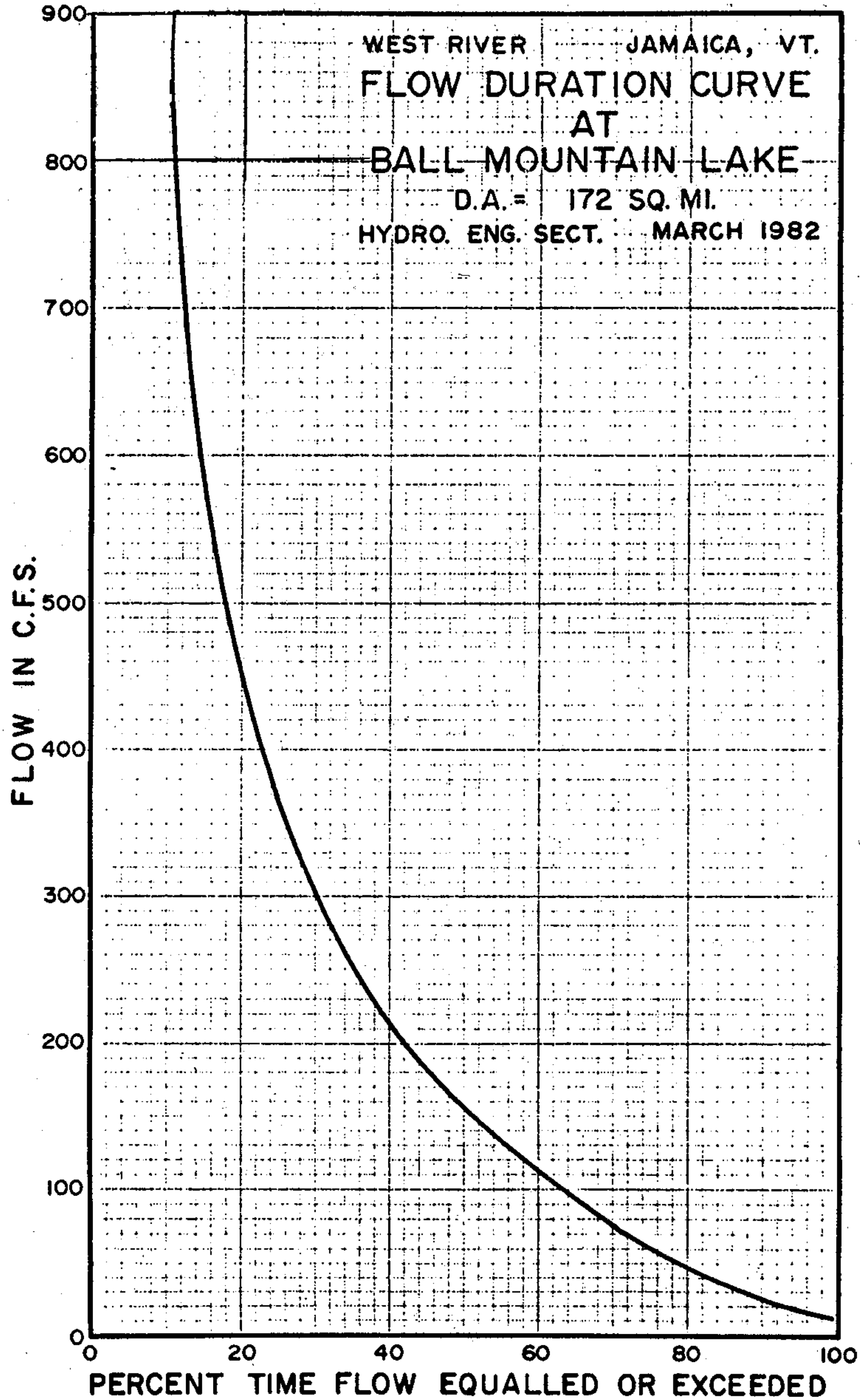

WEST RIVER JAMAICA, VT.
FLOW DURATION CURVE
AT
BALL MOUNTAIN LAKE
D.A. = 172 SQ. MI.
HYDRO. ENG. SECT. MARCH 1982
FLOW IN C.F.S.
900
800
700
600
500
400
300
200
100
0
0
20
40
60
80
100
PERCENT TIME FLOW EQUALLED OR EXCEEDED

FIGURE 9

TABLE 3

AVERAGE MONTHLY FLOWS (34 YEARS THROUGH 1980)
WEST RIVER IN JAMAICA, VERMONT
(D.A. = 179 Square Miles)

Month	Average Flow		Percent Annual Runoff	Maximum Monthly		Minimum Monthly	
	CFS	Inches		CFS	Inches	CFS	Inches
January	272	1.75	6.3	756	4.87	68	.44
February	241	1.40	5.1	702	4.08	41	.24
March	562	3.62	12.9	1,486	9.57	107	.69
April	1,315	8.20	29.4	2,423	15.10	584	3.64
May	583	3.75	13.4	1,464	9.43	187	1.20
June	227	1.41	5.1	619	3.86	36	.22
July	111	.71	2.5	475	3.06	14	.09
August	104	.67	2.4	913	5.88	17	.11
September	109	.68	2.4	471	2.94	13	.08
October	220	1.42	5.2	865	5.57	17	.11
November	332	2.07	7.4	717	4.47	68	.42
December	344	2.22	7.9	850	5.47	79	.51
Annual	367	27.9		610	74.3	161	7.75

Approximately 250 feet downstream of the existing outlet structure there is a moderately flat, wide area situated on the left bank of the outlet channel for location of a powerhouse. The existing outlet tunnel would be extended 250 feet and a new flood control gate structure constructed adjacent to the powerhouse. This extension would provide an additional head of 20 feet. Assuming head loses, this would result in a total net head of 80 feet for power generation. A branch penstock approximately 50 feet in length would lead from the outlet extension to the powerhouse. A 300-foot long tailrace would return the water used for generation to the West River. This layout would apply to either a single unit or multiple unit turbine installation.

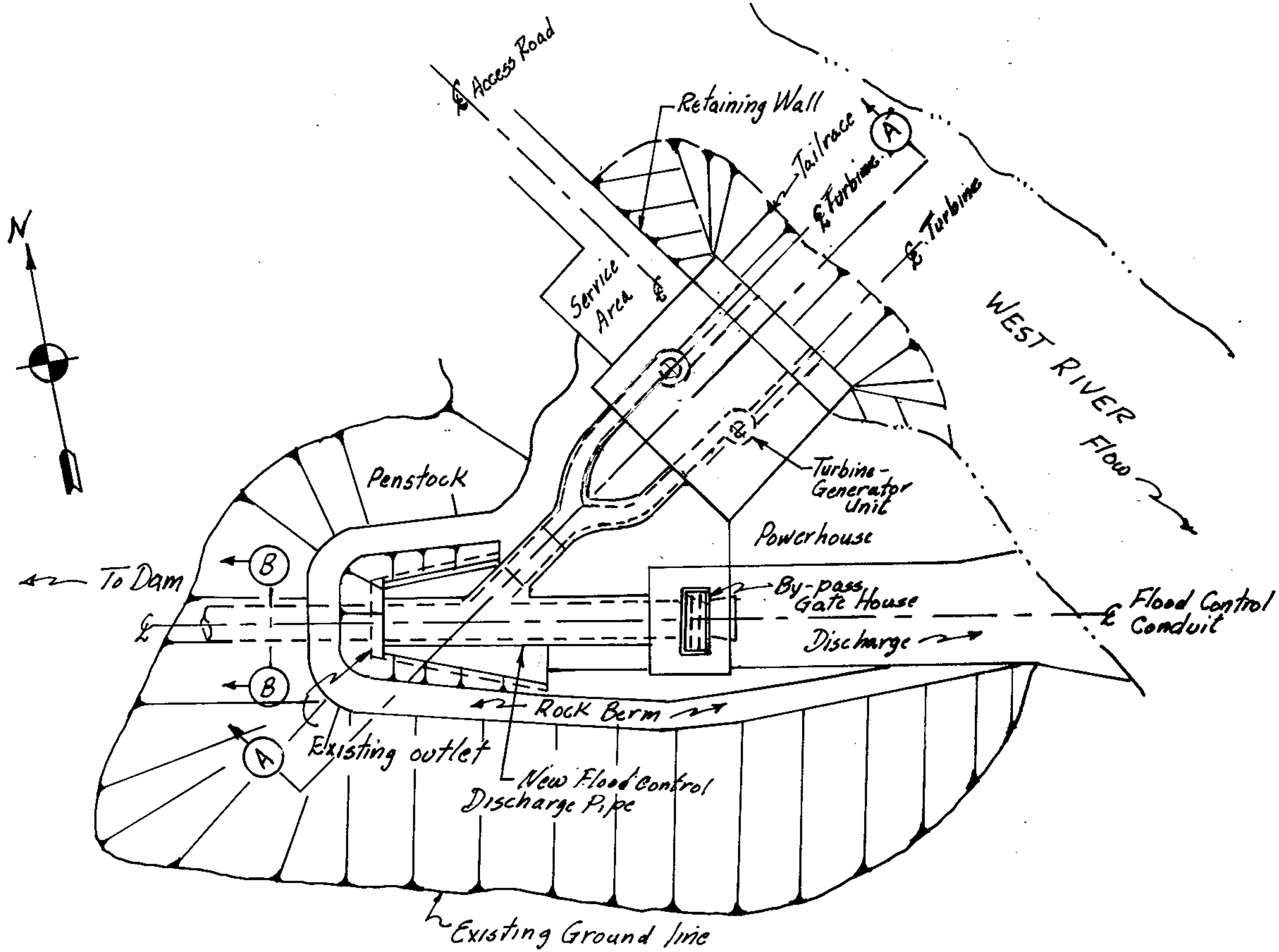
It may be possible to increase the available head for power generation by locating the powerhouse further downstream since the streambed of the West River in the 3-mile reach below Ball Mountain Dam drops 50 feet per mile. However, any siting of the powerhouse further downstream than the immediate vicinity of the dam could create a condition in which pressure surges could occur in the penstock in the event of load rejection or sudden valve closure. This water hammer effect and the need to accommodate it with hydraulic appurtenances such as a surge tank would require evaluation.Due to the limitation of funds for this study, evaluation of an alternative for power development at a downstream point where a surge tank may be needed will be deferred until the feasibility report stage. Thus alternatives for development of hydropower have been limited to a location powerhouse downstream of the outlet works of the Ball Mountain Dam.

DESCRIPTION OF PLANS CONSIDERED

Flow duration analysis was performed on three alternative plant configurations at this site as follows: a single vertical propeller turbine installation, a two-unit installation having turbines of equal size, and a two-unit installation having turbines of unequal size, one being approximately twice the size of the second.

A single 1400-killowatt unit would have a hydraulic design flow of 257 cfs and would produce an average 6,750 megawatt hours annually. With alternative 1, generation would occur with flows between 103 cfs to 270 cfs. Whenever inflow to the reservoir was less than 103 cfs, generation would cease and outlet discharge would be maintained approximately equal to inflow. The project would operate at full design capacity about 27 percent of the time, generally during the spring snowmelt period in March, April and May. Flows in excess of the turbine overload capacity of 270 cfs wuld pass through the new flood control outlet.

The second alternative consisting of two equal-size 1000-KW units, would have a total hydraulic design flow of 404 cfs and would produce an average of 9,067 megawatt hours annually. For a run-of-river operation this installation would have a greater operating range than a single unit installation. With alternative 2, generation would occur with flows between 80 cfs and 424 cfs. Whenever inflows exceed the two turbines combined, overload capacity of 424 cfs, flows would be diverted through the flood control gates. Whenever flows were less than 80 cfs, outflow would be maintained approximately equal to inflow. The project would operate at design capacity 21 percent of the time. A typical sketch of this installation is shown on Figures 10 and 11.



POWERHOUSE PLAN

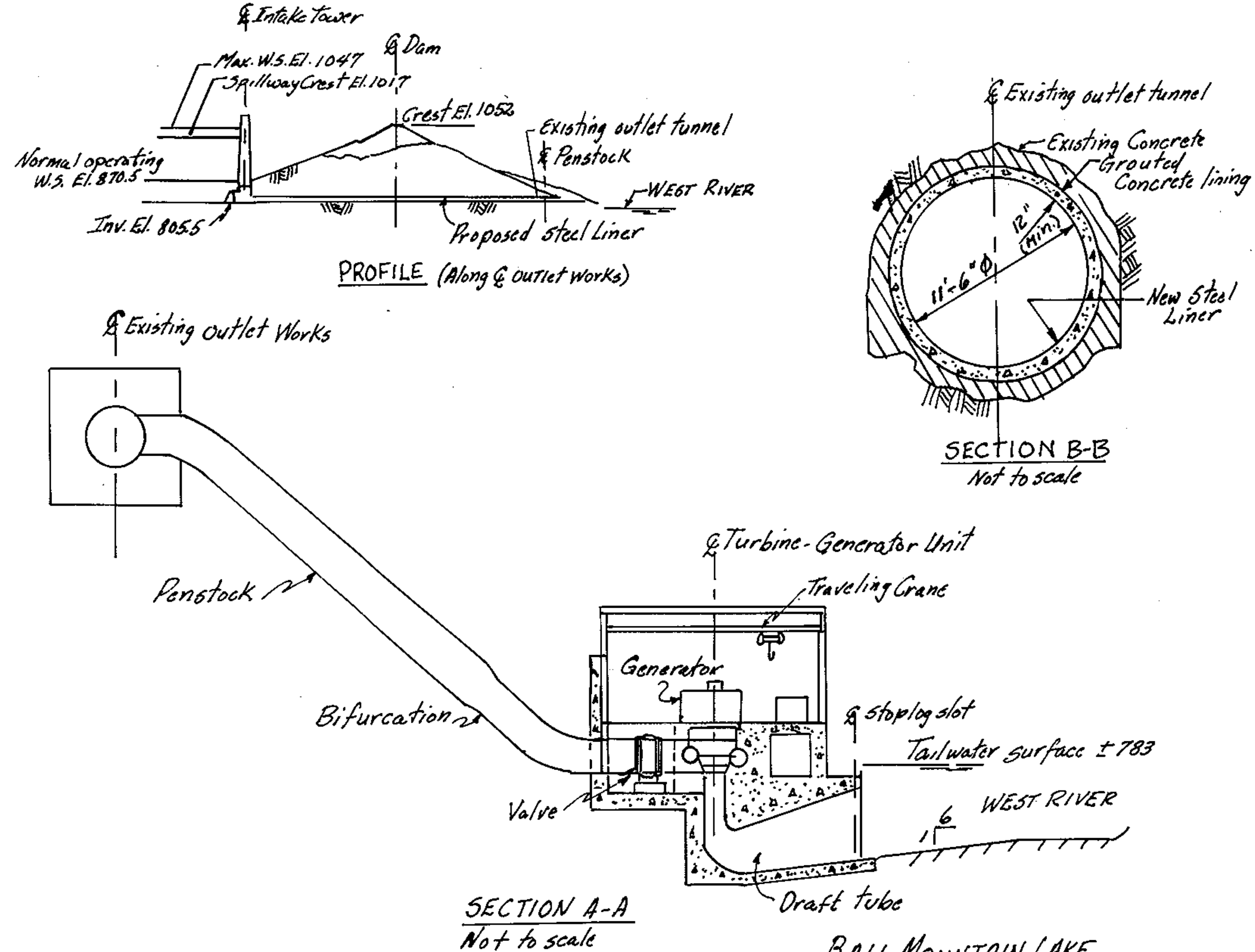
Not to scale

BALL MOUNTAIN LAKE

GENERAL PLAN

ALTERNATE 2

FIGURE 10



BALL MOUNTAIN LAKE
PROFILE - SECTIONS
ALTERNATE 2

FIGURE 11

It was further determined that by utilizing two equal-size units the added benefit of being able to interchange parts would be advantageous over the loss of minimal added energy obtained from two unequal units of different types. Therefore, no further consideration was given to unequal sized units.

Comparative data for both alternatives are shown in Table 4.

TABLE 4
PERTINENT DATA FOR HYDROPOWER DEVELOPMENT

	Alternative 1	Alternative 2
Number of Units	1	2
Throat Diameter (mm)	1,000	1,000 each
Hydraulic Head (feet)	80	80
Average Plant Flow (cfs)	257	404
Generator Type	Synchronous	Synchronous
Generator Capacity	1,400 KW	2,200 KW
Potential Annual Generation (Kwh)	6,750,000	9,067,000
Plant Factor	0.55	0.47
Turbine/Generator Efficiency	80%	80%
Type of Turbine	Vertical Standard Tube Propeller	Vertical Francis

COST ESTIMATES

Cost estimates have been prepared by using standardized cost curves taken from the Corps publication entitled, "Feasibility Studies for Small Scale Hydropower Additions" guidance manual, supplemented by site specific estimates using standard engineering practices. Estimates of construction costs including contingencies for Alternatives 1 and 2 at August 1982 price levels are presented in Table 5 below.

Slide gates have been included for dewatering the units. Switchyard costs have been included for a site adjacent to the powerhouse. The costs of providing a 46KV tranmission line, approximately 2 miles long, connecting to an existing 46-KW transmission line owned by Central Vermont Power Services Company, reflects the cost of crossing mountainous, rocky terrain.

Access to the powerhouse site is difficult due to steep rock terrain below the dam abutments. Preliminary estimates include an access road adjacent to the north abutment of the dam for construction and maintaining the powerhouse and switchyard facilities.

TABLE 5
ESTIMATED CONSTRUCTION COSTS

Item	Alternative 1	Alternative 2
Access & Site Preparation	$ 371,000	$ 371,000
Environmental Controls	14,000	14,000
Tunnel Lining	390,000	390,000
Trashracks	10,000	10,000
Penstock	107,000	107,000
Bifurcations	14,000	28,000
Flood Control Structure	550,000	550,000
Powerhouse	348,000	570,000
Tailrace	29,000	29,000
Station Electrical Equipment	220,000	370,000
Miscellaneous Powerplant Equipment	73,000	82,000
Transmission Line	68,000	68,000
Turbine & Generator	800,000	2,000,000
Switchyard	100,000	140,000
Control of Water	60,000	60,000
Subtotal	$3,154,000	$4,789,000
Contingencies 20%	631,000	958,000
Total Construction Cost	$3,785,000	$5,747,000

For this report hydropower additions at Ball Mountain Lake are assumed to have an economic life of 50 years. Currently, as prescribed by law, Federal agencies use a 7-7/8 percent interest rate to determine economic feasibility. Construction time for either alternative under consideration would be about 18 months; interest during construction (IDC) is included in the cost estimate. The cost of operation and maintenance is estimated by multiplying the investment cost by 1.2 percent on the basis that the Corps as owner and operating entity would operate and maintain the small hydroelectric facility under consideration. During the life of the hydroelectric project, miscellaneous equipment and facilities would wear out and require replacement. A sinking fund has been included for these replacements taken as 0.1 percent of the total construction cost plus contingencies. The following Table 6 shows investment costs and annual costs for the considered alternatives.

TABLE 6
ANNUAL COSTS FOR ALTERNATIVES

Item	Alternative 1	Alternative 2
Total Construction Cost	$3,785,000	$5.747,000
ED/S&A (17%)	663,000	977,000
Total Project Costs	4,448,000	6,724,000
Interest During Construction	354,000	537,000
Total Investment	$4,802,000	$7,261,000
I&A (.08057)	387,000	585,000
OM&R (1.3%)	63,000	95,000
Annual Costs	450,000	680,000
*Energy Production Cost $(\frac{\text{mills}}{\text{Kwh}})$	66	75

*This assumes an average annual energy generation of 6,750,000 Kwh and 9,067,000 Kwh, respectively.

IV. EVALUATION OF PLANS

ECONOMIC EVALUATION

A hydropower installation at the Ball Mountain Lake project would normally be operated for intermediate generation and during winter peak load months. The project will produce additional peaking energy in all but the most adverse water years. Peaking energy in New England is supplied by oil-fired gas tubines. During the remaining hours of the 12-hour heavy load period energy is supplied by oil-fired steam-electric cycling power plants. All other light load and offpeak hours energy is supplied by base load nuclear, coal-fired and oil-fired steam-electric plants and some hydroelectric generation as available, all scheduled on the basis of economic dispatch by the New England Power Pool (NEPOOL). The costs of the hydroelectric alternatives were estimated by the New England Division and include project first costs, operation and maintenance costs and transmission line costs.

For the foreseeable future it appears that the alternative source of intermediate and peaking energy in New England will be from oil-fired generating units. Therefore, it is expected that hydropower produced for development at Ball Mountain Lake would displace some of the older expensive fossil fuel energy sources. The Federal Energy Regulatory Commission (FERC) has indicated that the alternative of a cycling coal-fired steam generating station to be the most likely in the absence of hydroelectric facilities at Ball Mountain Lake. The costs of the coal-fired alternative were estimated by FERC.

In view of the uncertain escalating prices of oil, this report uses the estimated at-market energy values prepared by FERC for a coal-fired plant as a measure of the economic benefits for hydropower development at Ball Mountain Lake which are definitely on the conservative side.

When FERC estimates the costs of the thermal alternative, two costs are addressed, the capacity and the energy costs. The addressed measure of the value of the hydropower project's generating capacity is the total of the thermal plant's amortized investment cost, transmission costs, replacement costs, and fixed operating and maintenance costs. The measure of the values of the hydropower project's energy production is the the total of the thermal plant's variable operation and maintenance costs and fuel costs. Since there is no dependable generating capacity associated with run-of-river hydropower additions, only the energy value is taken as an economic benefit. Using conventional power value calculation methods, FERC found that for an oil-fired combined cycle alternative the corresponding hydroelectric energy value for hydropower would be about 25 mills/kwh for Alternative 1 and 24 mills/kwh for Alternative 2.

In December of 1979 the Water Resources Council, which formulated procedures used by Federal agencies to evaluate water resource projects, indicated that real escalation in fuel costs should be considered when evaluating hydropower projects. Analysis which takes into account real fuel cost escalation is referred to as relative price shift or inflation-free, life-cycle cost analyses. FERC also determined an energy value using this method and found, that when projected real oil cost changes are considered, the value of run-of-river energy produced at Ball Mountain Lake is 95 mills/kwh for Alternative 1 and 100 mills/kwh for Alterntive 2.

The energy values used in this report are take from a letter, dated 9 August 1982, from the FERC. The letter is contained in the Correspondence Appendix. Table 7 shows benefits for Alternatives 1 and 2.

TABLE 7

ANNUAL BENEFITS (WITH OIL PRICE CHANGES)

Project	Energy Benefits	Capacity Benefits	Total
One 1,400 KW Unit	6,750,000 (.095)	0	641,250
Two Equal Units 2,200 KW Total	9,067,000 (.100)	0	906,700

PROJECT BENEFITS (WITHOUT OIL PRICE CHANGE)

Project	Energy Benefits	Capacity Benefits	Total
One 1,400 KW Unit	6,750,000 (.025)	0	168,750
Two Equal Units 2,200 KW Total	9,067,000 (.024)	0	317,608

Utilizing costs from the previous annual charges section, benefit-to-cost ratios are provided in Table 8 below for all possible cases.

TABLE 8

BENEFIT-TO-COST RATIOS

Project	Without Oil Price Changes	Including Oil Price Changes
One 1,400 KW Unit	$\frac{168,750}{450,000} = 0.38$	$\frac{641,250}{450,000} = 1.43$
Two Equal Units 2,200 KW Total	$\frac{217,608}{680,000} = 0.32$	$\frac{906,700}{680,000} = 1.33$

The Water Resources Council permits analysis which include the effects of changing fuel prices. The computation of benefit-to-cost ratio without taking into account oil cost changes is shown for sensitivity analysis only. The alternatives being considered are economically efficient using the current approved method of economic analysis.

SOCIAL, ECONOMIC, CULTURAL AND RECREATIONAL CONSIDERATIONS

Socioeconomic

Since these two alternatives would not involve any major structural additions or alterations to the existing project, social impacts would be insignificant during construction. Maintaining the existing reservoir pool at the summer pool elevation of 870.5 feet NGVD would not have a significant effect on recreational opportunities within the existing reservoir. Further study would be required to determine the effect on flood control operations of the existing project.

Historical and Archeological Resources

While there are no known prehistoric sites within the existing Ball Mountain Lake project area, a cultural resource reconnaissance will be undertaken and coordinated with further detailed hydropower studies to determine if there would be any affected areas from plant construction or power pool fluctuations.

Recreational and Natural Resources

Maintaining the 75-acre summer pool level should have no effect on the existing Corps managed picnic area or sightseeing. Some wildlife habitat and cold water trout fishing habitat could be impacted. The effect on fishing would depend upon the quality of the fishery; a pool fluctuation of 1 to 2 feet per day probably would not be conducive to establishment of a good fishery resource.

ENVIRONMENTAL CONSIDERATIONS

Implementation of either Alternatives 1 or 2 would result in the same environmental consequences. The proposed pool could fluctuate 1 to 2 feet per day during power generation. Maximum fluctuation would be in the order of 0.1 of a foot per hour. Higher seasonal fluctuations occur during flood control operations under existing conditions.

Physical Settings

It is not expected that the addition of the considered hydropower development would have any significant impact on the macrotopography of geology of the area. The increase water fluctuation could result in sloughing of the shoreline in steep areas during the first few years of operation. Project implementation may require remedial measures to stabilize the steeper natural slopes and sandy soils in the reservoir. Further study would be required to determine what areas are vulnerable and whether any mitigation procedures are necessary.

Aquatic Ecosystem

Water Quality

Water quality changes caused by hydropower development will depend on what changes are made to the existing impoundment and how it is operated. The proposed plan would use the existing summer pool level; if it uses the existing intake works and discharges at a constant rate during the day, it will not change water quality conditions in the lake during the summer. An intermittent daily discharge, such as for a peaking power operation, might change stratification patterns in the lake leading to temperature changes in the pool and downstream discharges. These temperature changes are expected to be minor; further study will be required if they are to be predicted accurately.

The present winter pool is 25 feet deep. Increasing this to 65 feet deep would strengthen the winter stratification patterns and lead to a slightly warmer winter discharge. There is also the possibility of DO depletion occurring in the hypolimnion and a consequent increase in lake iron levels due to reduction of iron in the sediments. However, this is unlikely since the summer pool typically has high DO levels in the hypolimnion.

The effects of hydropower development on the water quality in the West River below Ball Mountain Dam would not be significant unless a long penstock is installed from the dam to the powerhouse. Sections of the river bypassed by the penstock will suffer water quality degradation in the form of reduced flushing, increased temperatures, and lower DO levels.

Further studies would be directed towards the determination of site preparation needed to maintain water quality standards to protect downstream aquatic environment.

Aquatic Vegetation

Following the spring snowmelt period, the existing reservoir pool is raised from a stage of 25 feet to a stage of 65 feet for use as a conservation pool. This increase represents about 2 percent of the flood control storage capacity and increases the seasonally inundated area by 55 acres. A small amount of emergent aquatic vegetation would be lost, but would be reestablished along the perimeter of the power pool following stabilization of the pool shoreline. The majority of the topography is too steep to develop significant wetlands under natural conditions.

Fisheries

The proposed addition of hydropower could result in the loss of some existing fish habitat around the perimeter of the winter pool. Increasing the size of the pool and holding it to a 1- to 2-foot fluctuation would improve the nesting and nursey area for species that utilize the shallow water area along the periphery of the reservoir. The cold water fishery at the upper end of the lake could be affected.

Further study would be required to determine the impacts to the downstream fishery which depends on the quality of the water released from the outlet works.

Aquatic Wildlife

Inundation of the seasonal wetland vegetation could cause a loss of cover, food, nesting habitats for amphibians, waterfowl and aquatic furbears in the project area. Where the changes in pool elevation are seasonal, there should be no permanent overcrowding; in fact the longer reach of permanent shoreline may increase the aquatic associated population.

Terrestrial Ecosystem

Vegetation

Increasing the pool by 40 feet in depth would inundate about 55 acres of seasonal terrestrial vegetation changing it from perennial grasses and shrubs to an aquatic environment. This inundation is expected to kill some intolerent tree species. To avoid the hazards created by inundation, Corps of Engineers policy concerning hydropower projects has recommended clearing from 3 vertical feet above the target pool elevation to 5 feet below the 10-year frequency drawdown. (ER-415-2-1). This would require removing trees below the 875.5 elevation NGVD.

Increasing the pool elevation on a permanent basis would also result in raising the groundwater level around the lake shoreline. Changes in the soil saturation levels would affect some species of plants and trees resulting in a change in composition of species in the lower levels of the terrestrial zone.

Wildlife

Upland wildlife that use the reservoir area during the lower winter pool stages would be permanently displaced to similar habitats at higher elevations.

Many would adapt to new environmental conditions, while some species may be overcrowded by the loss of seasonal habitat where the existing habitat is at its maximum carrying capacity. The extent of impacts would be the subject of further study at later stages of planning.

Endangered, Threatened or Rare Species

Since present records do not indicate any listed Federal endangered or threatened species in the project area, no impacts are anticipated from the project implementation. However, a survey of rare or endangered plants would be made at a later stage of planning. Should endangered species be encountered, mitigation measures would be developed.

RESERVOIR REGULATION

Since the primary purpose of the existing project is flood control, all hydropower additions would be subservient to flood control activities. The control of operations would be retained by the Division Engineer through the Corps' Reservoir Control Center.

V. CONCLUSION

Althouth schemes for addition of hydropower facilities at Ball Mountain have been evaluated at WRBEC, that organization does not meet FERC requirements and can not, at present, legally submit a license application. It is also suspected that the WRBEC schemes might involve infringement on flood control storage which would interfere with the authorized purpose of the project and therefore would not be allowed.

Two separate run-of-river alternatives were formulated and evaluated by NED for the addition of hydroelectric generation facilities at the existing Corps of Engineers flood control project at Ball Mountain Lake, in Jamaica, Vermont. Results of this evaluation indicate that the addition of hydroelectric generation facilities is technically and economically feasible. The alternatives were designed as run-of-river projects which would cause little fluctuation in the pool and would not interfere with the existing authorized purposes of the project.

By maintaining the normal summer pool of 870.5 feet NGVD and constructing a powerhouse 250 feet downstream of the existing dam, a 1400-Kw hydropower installation could produce 6,750,000 Kwh of energy annually. A two-unit 2200-Kw installation could produce 9,067,000 Kwh of energy annually. The benefit-cost ratios for these developments based on the escalating price of oil are 1.43 and 1.33, respectively.

VI. RECOMMENDATIONS

It is recommended that study of hydropower development at Ball Mountain Lake proceed to the Feasibility Study stage where detailed analysis of preliminary findings as well as the formulation and evaluation of additional alternatives can be performed to optimize power generation and determine environmental, social and economic impacts of any proposed development.

ACKNOWLEDGEMENTS

This reconnaissance study was conducted by the New England Division, Army Corps of Engineers, under the general supervision of Mr. Joseph L. Ignazio, Chief, Planning Division and William F. McCarthy, Chief, Basin Management Branch. Investigations and technical review of the report were performed by an interdisciplinary team. Persons primarily responsible for the contents of this report are: Harmon Guptill, study management, Mary Donovan, design and cost estimates; Townshend Barker, water quality; Debora Wilson, hydrologic and hydraulic data; Robert Heald, operational concerns; and Joseph Finegan, reservoir regulation.

Preparation and distribution of this report would not have been possible without the cooperation of the Division's technical, clerical and administrative staff. Special thanks is extended to the entire Reprographics Branch staff and Mrs. Camille Santi of the Word Processing Center.

HYDROPOWER STUDY

BALL MOUNTAIN LAKE, VERMONT

Attachment to the Reconnaissance Report
Schedule of Work and Budgetary Data

DECEMBER 1982

Reference ER 11-2-101, Which States That:

BUDGETARY INFORMATION IS NOT TO BE RELEASED
OUTSIDE THE DEPARTMENT OF THE ARMY

SCHEDULE OF WORK AND BUDGETARY DATA

General

The addition of hydroelectric facilities to the existing Ball Mountain Lake, Vermont, flood control project is technically feasible and worthy of detailed investigation. A favorable detailed feasibility study could result in the recommendation for authorization by Congress. Subsequent to authorization and appropriation, advanced engineering plans to construct a project would be initiated. The reconnaissance report represents preliminary planning activities including a description of the project site, identification of problems, needs, opportunities, management and budget information for future detailed study activities. Estimates of cost for each major element of the detailed feasibilitly study and the schedule for study accomplishment are shown in Exhibits 1, and 2, respectively.

Constraints and Controls

During the detailed feasibility study structural and nonstructural measures which address study objectives would be considered. Should the plan formulation process reveal that an implementable plan for Federal participation not be forthcoming, then an unfavorable report would be prepared. The feasibility study results and recommendations for a favorable project implementation would be submitted to Congress for action thereon and made available to the general public.

The study process will follow current Federal and Corps of Engineers guidelines and policies.

To date, $10,000 has been expended on the investigation of adding hydroelectric facilities to the Ball Mountain Lake flood control project. The total current estimated cost of the feasibility study is $430,000. The proposed allocation of funding for FY 83 to initiate the feasiblity study is $63,000. The study is schedule for completion in FY 86. Detailed funding by fiscal year is as follows:

Appropriation History

FY 82	$10,000 (O&M Money)
Total to Date	10,000

Proposed Allocations

FY 83	$ 63,000 (allocated)
FY 84	100,000
FY 85	150,000
FY 86	92,000
Total	$430,000

A $10,000 funding limit for preparation of a reconnaissance report was set by OCE, NED Program Development and NED Operation Division.

Preparation of Feasibility Report

This reconnaissance report presents baseline condition in the study area and a brief analysis of some possible type of hydropower affirmative development, namely, run-of-river operation.

The feasibility study will address other alternative plans such as system coordination with hydropower development at Townshend Lake flood control project located 9.5 miles further downstream on the West River. Another alternative to be investigated would be to tunnel through Ball Mountain to a point further downstream on the West River to increase hydropower potential. The feasibility study will contain conclusions and recommendations reached based upon, but not limited to the following items of work:

Geotechnical Investigations
Hydrologic and Hydraulic Analysis
Fish and Wildlife Coordination
Environmental Investigations
Economic Analysis
Plan Formulation and Evaluation
Design and Cost Estimates
Real Estate Studies
System Studies for Power Integration
Transmission Studies
Marketing Studies
Water Quality Studies
Power Generation Studies
Public Participation
Social, Cultural and Recreation Studies
Institutional Studies

The feasibility study results would be documented in a report following detailed studies of selected alternatives and a selected plan chosen. In the event that a technically and economically feasible plan evolves, an EIS would be prepared and submitted to OCE along with the draft feasibility report for review and comments.

Exhibits 1 (Study Cost Estimates) and 2 (Work Sequence Diagrams) are shown on the following pages.

RCS: DAEN-CWB-12

STUDY COST ESTIMATE (PB-6) ($000) For use of this form, see ER 11-2-220	APPROPRIATION TITLE: General Investigations	NAME OF STUDY: Ball Mountain Lake Hydropower Study, Vermont (Conn. River Basin Auth Reports)
	CATEGORY: Surveys	
	CLASS: Comprehensive Studies	SUBCLASS: Authorization Reports from Level B Studies

LINE NO.	SUBACCOUNT NUMBER	SUBACCOUNT TITLE	CURRENT COST ESTIMATE: RECON-NOISSANCE PHASE 1/	CURRENT COST ESTIMATE: FEDERAL FEASIBILITY PHASE	CURRENT COST ESTIMATE: NON-FEDERAL FEASIBILITY PHASE	CURRENT COST ESTIMATE: TOTAL FEASIBILITY PHASE	PREVIOUS FEDERAL COST ESTIMATE AND DATE APPROVED (1 Jul 81)	REMARKS
	a	b	c	d	e	f	g	h
1	.01	Public Involvement		12		12	11	1/ To be funded under
2	.02	Institutional Studies		10		10	8	O&M Program.
3	.03	Social Studies		10		10	7	
4	.04	Cultural Resource Studies		10		10	7	
5	.05	Environmental Studies		45		45	48	
6	.06	Fish & Wildlife Studies		8		8	7	
7	.07	Economic Studies		15		15	13	
8	.08	Surveying & Mapping		8		8	6	
9	.09	Hydrology & Hydraulics Investigations		35		35	33	
10	.10	Foundations & Materials Investigations		15		15	14	
11	.11	Design & Cost Estimates		40		40	40	
12	.12	Real Estate Studies		7		7	7	
13	.13	Study Management		65		65	55	
14	.14	Plan Formulation		30		30	30	

DATE PREPARED	DIVISION / DISTRICT	REGION / BASIN	Page
15 June 1982	DIVISION: New England; DISTRICT:	REGION: New England; BASIN:	Page 1 of 2

EXHIBIT 1

☆ U.S. Government Printing Office : 1982 - 522-097/364

STUDY COST ESTIMATE (PB-6) ($000) For use of this form, see ER 11-2-220	APPROPRIATION TITLE: General Investigations	NAME OF STUDY: Ball Mountain Lake Hydropower Study, Vermont (Conn. River Basin Auth Reports)
	CATEGORY: Surveys	
	CLASS: Comprehensive Studies	SUBCLASS: Authorization Reports from Level B Studies

LINE NO.	SUBACCOUNT NUMBER	SUBACCOUNT TITLE	CURRENT COST ESTIMATE: RECON-NOISSANCE PHASE	FEDERAL FEASIBILITY PHASE	NON-FEDERAL FEASIBILITY PHASE	TOTAL FEASIBILITY PHASE	PREVIOUS FEDERAL COST ESTIMATE AND DATE APPROVED (1 Jul 81)	REMARKS
	a	b	c	d	e	f	g	h
1	.15	Report Preparation		30		30	30	
2	.20	Water Quality		15		15	10	
3	.21	Power Marketing Studies		5		5	-	
4	.22	Transmission Studies		5		5	-	
5	.31	S&A		65		65	54	
6								
7		TOTAL		430		430	380	
8								
9								
10								
11								
12								
13								
14								

DATE PREPARED	DIVISION / DISTRICT	REGION / BASIN	Page
15 June 1982	DIVISION: New England DISTRICT:	REGION: New England BASIN:	Page 2 of 2

EXHIBIT 1

ENG FORM 2204-R, May 82

REPLACES ENG FORM 2204, APR 77 WHICH IS OBSOLETE.

☆ U.S. Government Printing Office : 1982 - 5?? ???/???

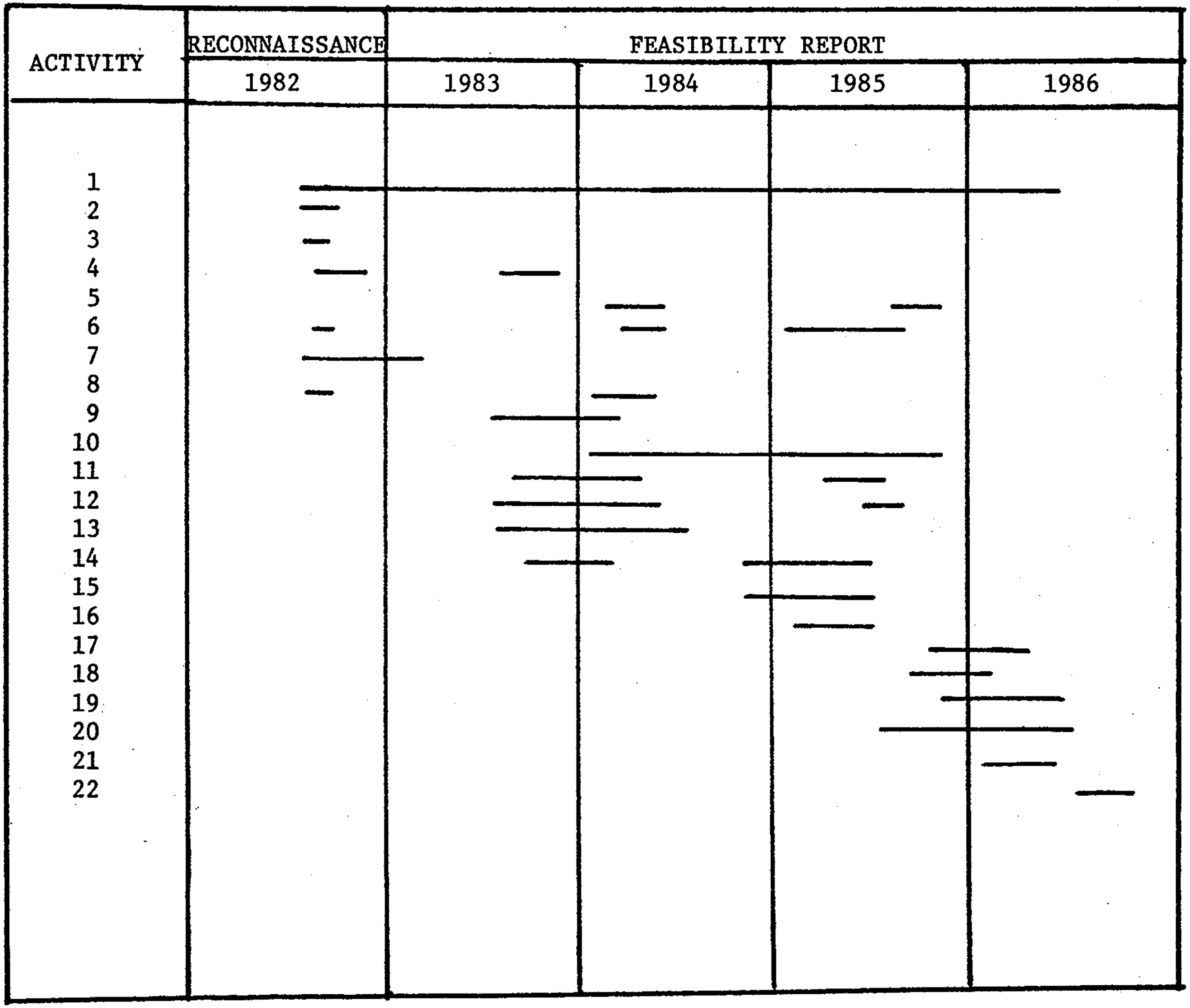

ACTIVITY
RECONNAISSANCE
FEASIBILITY REPORT
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EXHIBIT 2

1. Study Management and Public Involvement.
2. Baseline Environmental, Socioeconomic, Cultural and Recreational Conditions.
3. Preliminary Water Quality Data.
4. Power and Cost Estimates.
5. Real Fuel Cost Escalation by FERC.
6. Economic Analysis.
7. Reconnaissance Report and Review.
8. Formulation of Alternative Plans.
9. Power Estimates.
10. Environmental Studies to Fill in Data Gaps Identified by Baseline Studies.
11. Socioeconomic, Cultural, Recreation and Preliminary Real Estate Studies.
12. Water Quality Studies for Alternatives.
13. Design and Cost Estimates for Alternatives, including Geotechnical, Hydraulic, Transmission and Other Studies.
14. Economic Analysis and Marketing Studies.
15. Development of Final Plans.
16. Final Design and Cost of Power Estimates.
17. Real Estate Studies.
18. Final Water Quality, Recreation, Socioeconomic, Cultural and Institutional Studies.
19. Final Economic Analysis and Marketing Studies.
20. Plan Evaluation and Assessment.
21. Draft Feasibililty Report and Draft EIS (or EA).
22. Final Feasibililty Report and EIS (or EA).

EXHIBIT 2

FEDERAL ENERGY REGULATORY COMMISSION
NEW YORK REGIONAL OFFICE
26 FEDERAL PLAZA, ROOM 2207
NEW YORK, NEW YORK 10278

August 9, 1982

Colonel C. E. Edgar III
Division Engineer
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Edgar:

In response to your letter of March 12, 1982, and in accordance with subsequent discussions with members of your staff, we have determined at-market power values for the proposed inclusion of hydroelectric power at four of your existing flood control projects. The values were calculated by three different methods for annual plant factors of 19 through 69 percent in 10 percent increments for a federal interest rate of 7-5/8 percent. Capacity and energy values were computed as of January 1982 based on current construction and fuel prices (snapshot), and energy values were derived using life cycle cost (LCC) and displaced energy cost (DEC) techniques. The snapshot capacity values may also be used in conjunction with the LCC energy values to yield total LCC power benefits. LCC and DEC energy values are based on Department of Energy (DOE) projections released in November, 1981 and reflect levelized fuel costs for the 100-year period following the expected project on line date of 1988.

The power market was taken to be the New England Power Pool (NEPOOL). A baseload, coal-fired, steam plant was used to evaluate proposed installations with plant factors of 49, 59, and 69 percent, and a cycling coal-fired steam plant for 19, 29, and 39 percent plant factors. The capital costs, with federal financing, of generating plants installed on the NEPOOL system are $1,320/kW for a base load, coal-fired plant consisting of a single 600 MW unit and $920/kW for a single intermediate load 400 MW cycling coal unit. Heat rates are taken at 9,500 Btu/kWh for the base load coal plant and 11,000 Btu/kWh for cycling coal. A February, 1982 survey of the coal using utilities in NEPOOL showed the average cost of coal to be $2.30/million Btu's. The at-market values reflect the estimated cost of assumed 345 kV transmission required for delivery of output from the base load and cycling coal alternatives to market.

Snapshot power values consisting of two components, represent a summation of all the annualized costs of contructing and operating a power plant and required transmission for the year following an assumed on-line date during October 1982. The capacity component reflects the fixed costs associated with the construction and operation of the project alternative, with interest expense accounting for the largest portion. The energy, or variable component consists mainly of the cost of fuel consumed. In the case of the LCC values, the snapshot energy values are used as a starting point but are escalated to reflect the increased fuel costs for the 100-year period following the projected project on-line date of 1988. All energy costs were discounted to 1988 to obtain their present worth and then summed. A capital recovery factor was then applied to yield the levelized LCC energy value. The process for calculating the DEC energy value is essentially similar, but in this case it is the cost of the energy displaced in the project market area for each of the 100 years following 1988 which is escalated. The methodology for the displaced energy costs analysis is based on the recently issued Water Resources Council task force report entitled "Implementing Procedures for Evaluating Hydropower Benefits." The annual load duration curves for New England were synthesized from data supplied by NEPLAN for 1981 and future load projections from the Northeast Power Coordinating Council (NPCC) reliability report, submitted to DOE, and the NEPLAN "Red Book." The type of generation displaced was taken from capacity band stackings loaded economically on the annual load duration curve. The projections of capacity changes were also taken from the NPCC reliability report and the NEPLAN "Red Book." These provide information through the year 2002. After 2002 and through 2088, it was assumed that there would be no further change in the types of generation displaced.

Estimated at-market power values are shown on the attached table. The capacity values, rounded to the nearest dollar, are applicable to the project's dependable capacity and the energy values, rounded to the nearest mill, are applicable to the average annual generation.

If we can be of further assistance in your study, do not hesitate to contact us.

Sincerely,

James D. Hebson

James D. Hebson
Regional Engineer

Attachment
As Noted

New England Division - COE

"FOUR CORPS: PROJECTS AT-MARKET POWER VALUES

Annual Plant Factor	%	19	29	39	49	59	69
Alternative	Type	CCP	CCP	CCP	BCP	BCP	BCP
Power Values							
Jan.'82 Price Level							
Capacity	$/kW/Yr	127	127	127	182	182	182
Energy	Mills/kWh	18	26	30	24	25	27
Life Cycle Cost							
Energy	Mills/kWh	25	37	42	33	36	38
Displaced Energy Cost							
Energy	Mills/kWh	112	112	112	100	95	48

Notes: CCP - Cycling Coal Plant
BCP - Base Coal Plant